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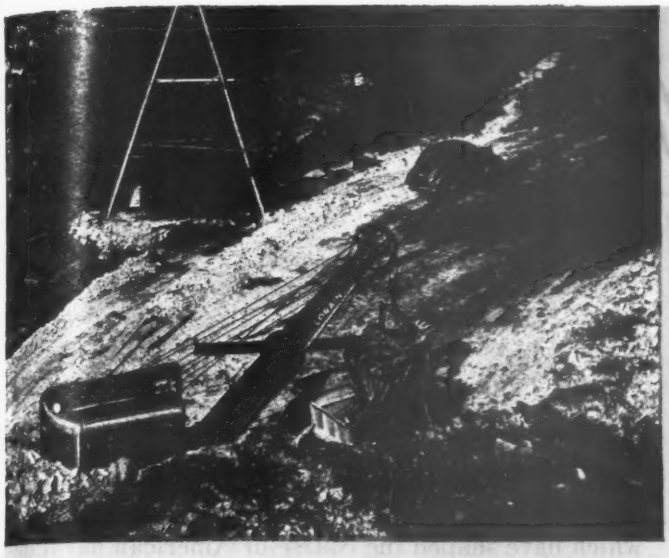

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The Course of Oil

by K. C. SCLATER

OIL'S HISTORY NEGLECTED

Despite the profound influence that petroleum has exerted upon our civilization, it is an astounding fact that the history of oil has been woefully neglected. This was the gist of an address, "History Looks at Oil," delivered by Paul H. Giddens before the members of American Petroleum Institute at Chicago last month. He observed, "Little has been done by individual oil men, oil companies, or the industry in general to make known its history or to honor those who played a leading role in the development of the industry." He points out, "There are many books on the scientific and technical aspects of the industry, but there are few that attempt to give the American people any appreciation or broad understanding of its history. There is no monumental history of the industry in several volumes to serve as a general reference for those who seek accurate, reliable, and objective information; there is no popularly written one-volume history for public consumption—of a best-seller type."

According to Giddens, "At least two factors have been responsible for the negative attitude taken by oil men toward their rich heritage. Some are indifferent because they believe that all one needs to do is to manufacture and sell a product noted for its fine quality; nothing more needs to be done. Others have been so engrossed in the material and scientific developments that they have not taken time to reflect upon the human reaction to what they were doing. Neither group has sensed the importance, even the necessity, in a democracy of having the people understand the background and problems involved in the development of a big business.

"Speaking on this point Professor Richard S. Meriam of Harvard University recently declared: 'In few industries of this country have businessmen done this part of their jobs worse than the oil men.' One might inquire: Of what value is it to build a great industry in a democratic state and then have an unappreciative and prejudiced public hinder and restrict its development by the passage of unjust and unwise legislation? Emphasis upon scientific research is exceedingly important, but in a century in which governmental control over industry has increased tremendously and the people exercise that control through their representatives in state legislatures and in Congress, even more attention ought to be given to the development of good will and a friendly public. Otherwise, the future becomes even more uncertain than the past."

Giddens goes on to show that oil men who believe that the history of the industry is adequately recognized and that there is no need to be concerned, are grossly mistaken. For example, "Let us examine several histories of the United States Navy written between 1936 and 1942. In *The Rise of American Naval Power 1776-1918* by Harold and Margaret Sprout, the authors say: 'This volume represents an attempt to assemble the historic pattern of conditions, institutions, events, ideas, motives, and personalities which have shaped the course of American naval development.' Yet there is not a single reference to oil. Their second book, *Toward a New Order of Sea Power 1918-1922*, gives a few lines about the British government and corporations succeeding in cornering most of the known petroleum reserves of Europe, Asia, and part of Latin America.

"Possessing an unusual advantage for writing on naval history, Captain Dudley W. Knox, U.S.N., a graduate of the Naval War College and for many years in charge of the archives of the Navy Department, has written *A History of the United States Navy* without mentioning oil. The publisher of Fletcher Pratt's book, *The Navy: A History*, says: 'This is the first inside history of the American Navy ever to be written. Prepared by a distinguished authority on the subject, it is a dramatic, authentic account of the development of our Navy from its earliest beginnings to the present day.' Pratt does not mention oil. One might think that a gigantic conspiracy had been formed by writers to ignore petroleum as a factor in naval warfare. Strange to say, each one of these authors has omitted any reference to the fact that the Navy conducted significant experiments with oil as fuel almost continuously after 1864, to the efforts of Rear Admiral George W. Melville to create an oil-burning fleet, to the significant investigation of petroleum as fuel by the Liquid Fuel Board in 1902-03 which proved so tremendously important to the entire naval and commercial world, to the decision to make the Nevada the first battleship to burn oil exclusively in any Navy, to the need for creating naval petroleum reserves, and to the particular contribution of oil in serving our destroyers on convoy and patrol duty in World War I."

An examination of the texts on American history in the public schools of this country discloses a similar lack of appreciation and understanding of the oil industry, according to Giddens.

A vigorous approach and plea to remove this shortcoming and compile a history worthy of petroleum has been made by Giddens, whose efforts merit the wholehearted support of the oil industry.

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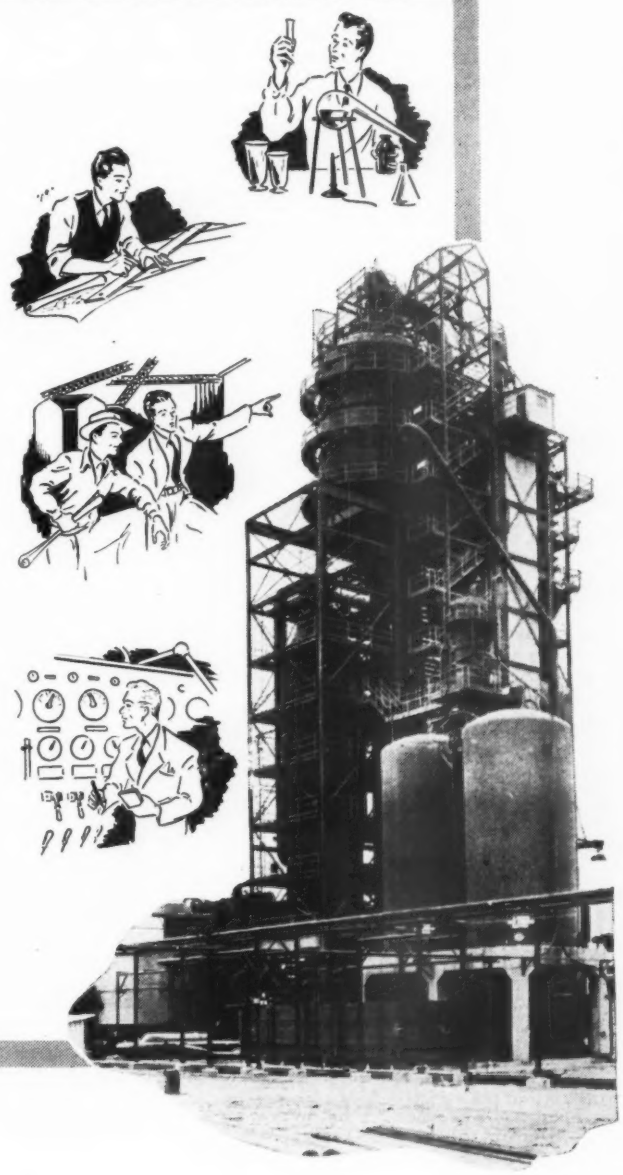

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Scanning WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—All this talk of dwindling reserves, declining rate of discoveries, and enormous future demands, with military authorities joining in the chorus, is creating an explosive atmosphere for oil.

President Truman is sensitive to suggestions from the military. He is more impulsive, more unpredictable than Roosevelt. Congress is aware that the people fully realize their utter dependence on oil, in peace or war.

True, there are no proposals now for governmental control or operation. Indeed, even Secretary Ickes says he believes "the job should be done by private enterprise to the fullest extent that this may be possible." But there is an unspoken "or else" undertone that has dangerous potentialities. The job expected of industry is enormous, the difficulties many—including those political.

Military authorities say 30 to 40 billion barrels of accessible reserves are needed to sustain the productive capacity of 2 billion barrels annually for five years, which they estimate as the minimum for military, industrial, and civilian requirements in event of another war.

Both the Army and Navy unqualifiedly insist that the industry can do the job. They urge that the government lend every encouragement and assistance, here and abroad. But will that help be forthcoming? And if it isn't, what will the military do then? While all-out in their advocacy of private enterprise, military leaders feel strongly their responsibility for national defense.

Ickes and the military are vying for control of the government set-up to work with the industry in developing adequate oil productive capacity.

The military proposes a small, select group of industry leaders joining with top-flight Army and Navy officials, plus a sprinkling of other government representatives in case their help is needed.

Ickes believes that Interior Department should be the agency to deal with the industry, and vice versa. He feels that Interior is responsible for assuring the military of adequate oil reserves. And he is quietly working to that end. He is attempting to bring all government lands under Interior, including naval reserves; also, he wants the submerged lands from low tide out to the farthermost reaches of the continental shelf. Study is being made of underground stockpiling here of foreign oil. Ickes also is considering a stripper well subsidy program, which some producers fear would be "the camel's nose under the tent."

So, Ickes may not be clamoring for federal control now, but he is not inactive on the oil front.

● **PUBLIC LANDS.** Secretary Ickes is taking sharp issue with many provisions of the bill (S. 1236) by Senator O'Mahoney, Wyoming, to amend the public lands oil and gas leasing law.

Ickes is opposed to any extension of the 12.5 per cent royalty rate beyond the present provision allowing this flat rate for 10 years on discoveries during the war emergency. (The industry wants this flat rate extended to all government oil and gas leases.) The O'Mahoney Bill would extend the flat rate to discoveries during the life of any lease entered into during the war.

He is particularly opposed to the bill's provision that the Secretary of Interior must accept royalty in kind, if he is not satisfied with the posted field price as basis for royalty payments.

On liberalizing acreage limitations, Ickes suggests the limit for one operator in any one state be increased from the present 7,680-acre limit to 12,230 acres with a proviso that the Secretary, in his discretion, could up it to 20,000 acres. (The O'Mahoney Bill would double the present limit to a flat 15,360 acres.) Ickes is agreeable to removal of the 2,560-acre limit on any one producing structure.

The bill would allow a 2-year option on 100,000 acres in any one state for geophysical work, but Ickes would cut this to 64,000 acres.

Ickes proposes that the law be changed to make Interior the lessor for all government oil and gas lands except those in Naval Petroleum Reserves, local areas and national monuments, and parks. (This would take away from Agriculture Department its authority over oil and gas leasing on some 165,000,000 acres.)

Ickes is willing to go along with the bill's provisions allowing unitization of parts of fields or pools, delegation of the Secretary's authority over a unit plan's operations, and relinquishment of a lease without approval of Interior.

● **UNITIZATION TAX.** An effort is being made to have Internal Revenue Bureau issue an interpretation clarifiying the tax status of unitized field operating committees. It is believed that one controlling factor in such a ruling will be whether or not the owners granted, for an indefinite period of time, an irrevocable right to sell their product.

● **ALASKAN OIL.** Navy is seeking $8,900,000 from Congress to complete exploration of Navy Petroleum Reserves No. 4 in Point Barrow, Alaska, which was begun last year with Navy Seabee personnel. A well at Umiat Mountain was down to 1860 ft. when operations were shut down at close of last summer. It is proposed to have private contractors carry on the exploration. Funds to continue for another year are available now.

If reserves of 400 to 500 million barrels, supporting a productive capacity of 100,000 bbl. a day are found, it is proposed to build a 16-in. pipe line via Fairbanks to the sea. This would cost between $60,000,000 and $90,000,000.

● **SURPLUS 100-OCTANE.** Army-Navy Petroleum Board wants to have a voice in disposal of surplus 100-octane gasoline, believing it can get a better price for it than if RFC puts the material on the auction block. Refiners will watch with interest since ANPB has 18,000,000 bbl. of 100-octane on hand in this country, plus another 20,000,000 bbl. abroad.

● **PIPE LINE DISPOSAL.** Disposition of the Big Inch pipe lines is still anybody's guess, but their use for oil is becoming probable. Military authorities want that. Senator O'Mahoney is working to remove the anti-trust obstacle, which might stand in the way of joint operation by a group of companies.

● **POSTSCRIPTS.** Oil field equipment manufacturers are pressing OPA to remove price ceilings on their products . . . Russian refinery throughput was increased 40,000 bbl. a day, including capacity for 7000 bbl. a day of 100-octane equivalent, with equipment supplied from the U. S. A. during the war . . . RFC has a proposal for use of Florida Emergency Pipeline to haul liquefied petroleum gas, with pressurized barges feeding the western end from the Gulf Coast and hauling off the Jacksonville terminal as far as Richmond, Virginia . . . Filing of the government's motion to put the API anti-trust suit back on the active docket has opened the door to a resumption of negotiations for a consent decree settlement.

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NATIONAL PETROLEUM SITUATION

GREATER GASOLINE SUPPLY. November marked a sharp upturn in refinery motor fuel production. Daily output was 2,287,000 bbl., while total domestic and foreign consumption averaged 1,991,000 bbl. daily. As a result, motor fuel stocks increased nearly 9,000,000 bbl. in November. The yield of refinery gasoline from crude was stepped up to 43 per cent, from 42 per cent in October and 40.7 per cent a year ago.

NATURALS OUTPUT INCREASED. In line with stepped-up production of motor fuels in November, production of natural gasolines was substantially greater. Daily production is estimated at 311,000 bbl., against about 250,000 bbl. daily in October. Seasonally greater demand for natural gas, with corresponding increase in extraction plant operations, added materially to available natural gasoline supply in November.

FUELS OUTPUT RETARDED. Greater concentration upon production of motor fuels in November, with greater than normal stock build-up, had the effect of retarding needed production of fuel oils. Stocks of light and heavy fuel oils are about 13 per cent below a year ago, in the face of predictions for heavier than expected demand for fuel oils. Fuel oil production this year is 6 per cent under last year, while demand is about 2 per cent ahead of last year.

INCREASED FIELD OPERATIONS. Well completions in November totaled 2,330 against 2,286 in October and 2,225 a year ago. Cumulative completions are 21 per cent above last year and are within a fraction of 1 per cent of the cumulative quota for 1945. Wildcat completions, however, continued to lag behind the quota and are expected to fall short of the 5,000 mark by at least 825 wells. All areas except Kansas, Arkansas and Illinois have shown substantial gains in drilling activity. Over 2,800 more wells were contributed this year by Texas, California, Oklahoma, Louisiana and Mississippi. Mississippi has shown an increase of 169 per cent in new wells completed this year over last year.

PRICE PARAMOUNT FACTOR. The price of crude oil is still the paramount factor in the petroleum industry's postwar outlook. Repeated efforts to eliminate the subnormal price ceilings have been of no avail. The index of wholesale prices of all commodities, compared with crude oil, places this commodity at 61, against 105 for all commodities. Urgent appeals to operators to drill more wildcat wells in the needed search for new oil fields are futile in the face of constantly rising costs with no corresponding advance in crude oil prices. An intensified search for new and much needed reserves cannot be expected until there is an incentive in the form of higher crude prices.

Comparative Statistics, November, 1945

*All figures are computed on a Bureau of Mines basis**

	Nov. 1945	Oct. 1945	Nov. 1944	This year to date	Last year to date	Per cent change
Wells drilling	4,155	4,130	4,370	4,155	4,370	— 5
Total wells drilled	2,330	2,286	2,225	24,698	20,389	+21
Development wells	1,969	1,918	1,894	20,893	16,892	+24
Oil	1,149	1,134	1,134	12,680	11,512	+10
Gas	264	241	232	2,374	1,990	+19
Dry	556	543	528	5,839	3,390	+72
Per cent dry	28.2	28.3	27.9	27.9	20.1	+ 7.8
Wildcat wells	361	368	331	3,805	3,497	+ 9
Oil	44	48	40	503	431	+17
Gas	10	7	6	123	110	+12
Dry	307	313	285	3,179	2,956	+ 8
Per cent dry	85.0	85.0	86.1	83.5	84.5	— 1.0
Crude production	131,400	123,980	142,404	1,560,139	1,532,471	+ 2
Daily average	4,380	3,999	4,747	4,671	4,575	
Crude demand†	139,485	127,755	146,355	1,628,886	1,593,155	+ 2
Daily average	4,649	4,121	4,879	4,877	4,756	
Crude stocks	222,390	226,900	229,241	222,390	229,241	— 3
Days supply	48	55	87	48	48	
Natural gasoline production	9,320	8,020	8,824	100,622	91,049	+11
Daily average	311	250	294	301	272	
Motor fuel production	68,600	61,690	64,842	735,814	677,684	+ 9
Daily average	2,287	1,990	2,161	2,203	2,023	
Gasoline yield, per cent	43.0	42.0	40.7	40.3	39.3	+ 1.0
Motor fuel demand	59,740	65,660	62,447	741,126	676,332	+10
Daily average	1,991	2,118	2,082	2,219	2,019	
Motor fuel stocks	77,380	68,450	72,441	77,380	72,441	+ 7
Days supply	39	32	35	39	35	
Fuel oil production	58,200	54,830	58,240	658,599	698,511	— 6
Daily average	1,940	1,769	1,941	1,972	2,085	
Fuel oil demand	57,100	60,300	64,541	709,209	693,808	+ 2
Daily average	1,903	1,945	2,151	2,123	2,071	
Fuel oil stocks	87,810	85,120	101,227	87,810	101,227	—13
Days supply	46	44	47	46	47	
Refinery still runs	140,300	130,070	140,045	1,577,853	1,520,559	+ 4
Daily average	4,672	4,196	4,668	4,724	4,539	
All refined stocks	242,050	227,280	253,564	242,050	253,564	— 5
Days supply	51	46	49	51	49	

*Unless otherwise stated all figures represent thousands of barrels.
†Domestic and foreign. ¶Revised.

Economic Position of U. S. Petroleum Industry

Eleven months ending November 30, 1945

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	24,716	24,698	99.3
Production (daily crude output)	4,682	4,671	99.3
Refining (daily still runs)	4,873	4,724	96.9
Stocks (crude and refined)	487,240	464,440	95.3
Price of crude (per barrel)	$1.99	$1.22	61.3

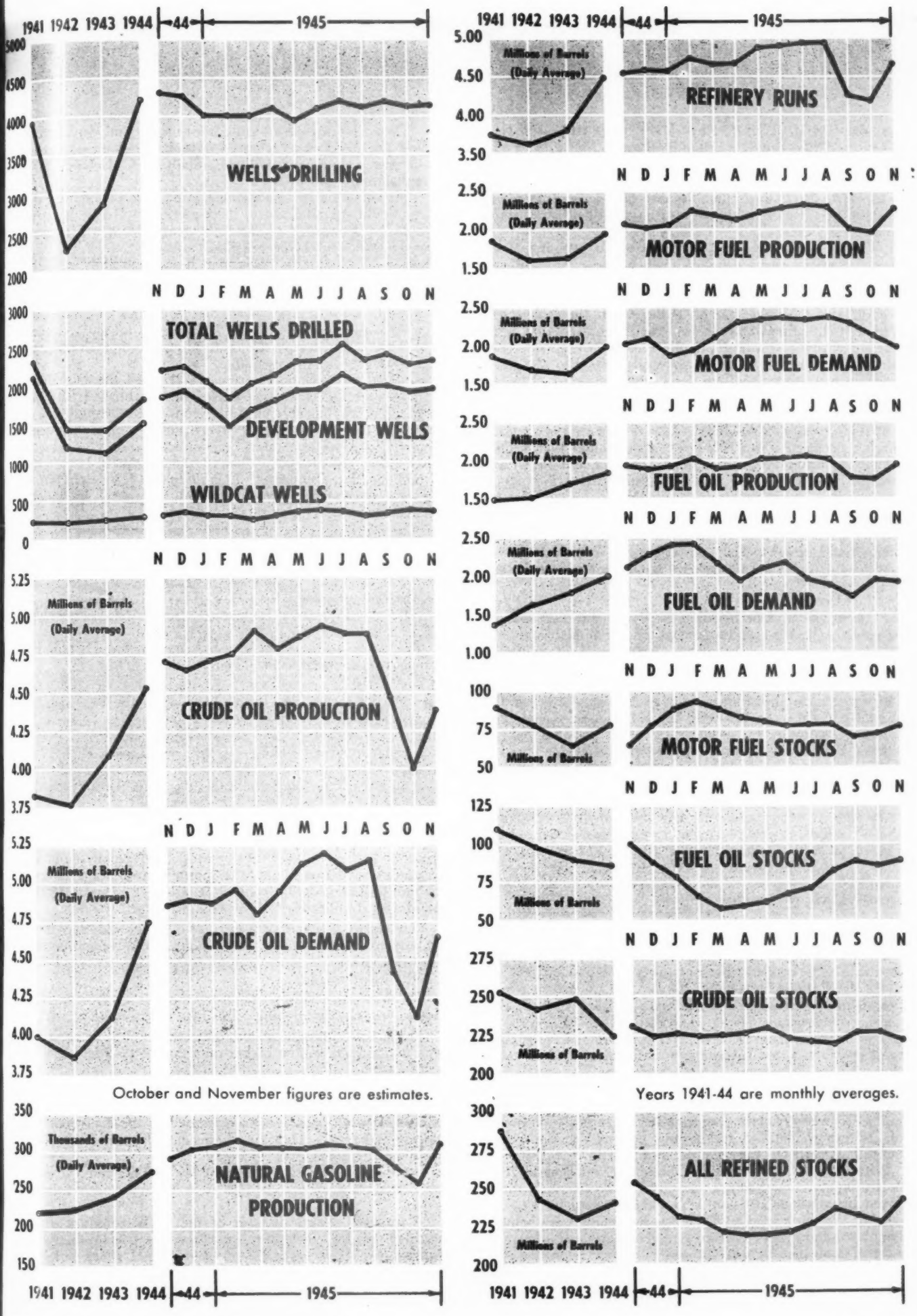
Crude Prices by States for November, 1945§

U. S. average	$1.22	Louisiana	$1.20	**Basic crude prices**	
Texas	1.23	Arkansas	1.25	Oklahoma-Kansas (36 gr.)	$1.17
California	1.07	New Mexico	1.04	Texas Gulf Coast (36 gr.)	1.40
Oklahoma	1.17	Mississippi	1.10	East Texas	1.25
Kansas	1.17	Illinois	1.37	West Texas (36 gr.)	1.04
		Other states	1.89	Calif. Signal Hill (26 gr.)	1.11
				Pennsylvania	3.00

Drilling and Production Statistics by States

	Nov. 1945	Oct. 1945	Nov. 1944	This year to date	Last year to date	Per cent change
Total wells drilled	2,330	2,286	2,225	24,698	20,389	+ 21
Texas	616	576	520	6,605	5,166	+ 28
California	146	183	160	2,048	1,800	+ 14
Oklahoma	229	155	203	2,208	1,617	+ 37
Kansas	167	157	176	1,605	1,698	— 5
Louisiana	116	93	86	1,046	719	+ 45
Arkansas	15	18	14	158	249	— 37
New Mexico	26	46	26	377	363	+ 4
Mississippi	28	39	20	341	127	+169
Illinois	171	157	217	1,649	1,715	— 4
Other states	816	862	803	8,761	6,935	+ 26
Wildcats drilled	361	368	331	3,805	3,497	+ 9
Texas	146	120	115	1,442	1,244	+ 16
California	16	30	16	224	183	+ 22
Oklahoma	37	27	38	418	342	+ 22
Kansas	37	33	41	351	471	— 25
Louisiana	15	12	14	157	122	+ 29
Arkansas	4	4	6	37	58	— 36
New Mexico	3	14	3	77	57	+ 35
Mississippi	13	11	7	121	73	+ 66
Illinois	37	35	40	341	345	— 1
Other states	53	82	51	637	602	+ 6
Daily crude production	4,380	3,999	4,747	4,671	4,575	+ 2
Texas	1,874	1,506	2,149	2,055	2,037	+ 1
California	832	821	878	898	849	+ 6
Oklahoma	378	364	362	376	339	+ 11
Kansas	250	263	273	265	271	— 2
Louisiana	358	353	354	356	353	+ 1
Arkansas	74	74	80	78	80	— 2
New Mexico	94	100	105	103	108	— 5
Mississippi	51	52	50	51	44	+ 16
Illinois	202	188	209	204	212	— 4
Other states	265	278	287	285	282	+ 1

§No change since prices frozen. Prices do not include subsidies.
(p) Preliminary. ***Does not include input wells.



October and November figures are estimates.

Years 1941-44 are monthly averages.

Highlights IN OILDOM

● **OIL PRODUCTION RESUMES ON TARAKAN.** Oil production in the Tarakan fields off Borneo, first territory in the Netherlands Indies to fall to the Japanese, has been resumed on a limited scale, the Batavian Oil Company reports. No estimate was made for 1945 output, because full scale production has been made impossible by the destruction of field equipment and storage facilities.

When the Japanese invaded Tarakan in January, 1942, the Dutch garrison destroyed most of the existing wells and storage tanks. During the Japanese occupation, American bombers struck the fields in November, 1944. The Japanese attempted to follow a "scorched-earth" policy when the island was invaded by the allies this year. An examination revealed, however, that one-third of the wells in the Pamusian area were not destroyed, and almost half the new wells drilled by the Japanese were in operating condition.

In 1940, crude oil production amounted to 807,821 long tons, but declined to 698,284 in 1941. Drilling was continued throughout 1940 because of the demand for oil but lack of cargo space limited production in 1941. The company noted that despite the Dutch destruction and American bombing, the Japanese succeeded in operating the wells and even drilled 140 new tests.

● **W. R. BOYD, JR., HONORED FOR WAR SERVICE.** Washington officialdom joined with oil industry leaders from all over the nation December 11 to pay tribute to William R. Boyd, Jr., and his distinguished war service as chairman of the Petroleum Industry War Council.

PIWC, the petroleum industry's national war agency created by the Petroleum Administrator for War to aid the Federal Government with its wartime petroleum planning, tendered the testimonial dinner in honor of Chairman Boyd at the Hotel Statler.

As a token of the esteem with which he is held within the industry and in appreciation of the selfless and successful service he performed in directing the oil industry's enviable war efforts, Chairman Boyd was presented with an oil portrait of himself and a silver waiter bearing the signatures of all those who served with him as members or on the executive staff of PIWC.

Cabinet officers, diplomats, senators, congressmen, army and navy officers, other public officials and men from all phases of the oil industry were in attendance at the dinner, at which Petroleum Administrator for War Harold L. Ickes and Deputy Petroleum Administrator for War Ralph K. Davies extolled Chairman Boyd as one of the founders of a new age in government-industry partnership.

● **OVERSEAS PETROLEUM SURPLUS DISCUSSED.** Officials of the Office of the Foreign Liquidation Commissioner have met with top representatives of the petroleum industry to explain the status of and offer information on overseas surplus petroleum installations and storage facilities. Thomas B. McCabe, commissioner, has announced.

The meeting, the first of several with various industries, arranged by the Fixed Installations Division of FLC in cooperation with the Petroleum Administration for War, was attended by 30 industry officials representing the following oil companies: Standard-Vacuum, California Texas Oil Company, Atlantic Refining Company, Intava Incorporated, Standard Oil Company of California, The Texas Company, Socony-Vacuum Oil Company, Inc., Gulf Oil Corporation, and Asiatic Petroleum.

After an official welcome by Major General Donald H. Connolly, deputy commissioner, Colonel Sidney Gruneck, director, Fixed Installations Division, who presided, explained to the oil officials that bulk sales to foreign governments were being contemplated and that FLC desired to give American industries information on the surpluses in case they were interested, before any foreign government bulk sales were made, stressing that "time is of the essence."

"These meetings are purely informatory and explanatory, to allow the industry to know in advance what we have to offer and give it the opportunity to submit bids," Colonel Gruneck emphasized.

Colonel Gruneck also pointed out to the oil officials that if they would submit a list of their needs by foreign countries, it would be forwarded to the field commissioners for whatever consideration might be possible.

After a round-table discussion it was mutually agreed that all oil firms would be given until December 15 to submit to FLC their indications of interest in any surplus in Italy, which was the major topic of discussion. The discussion also brought out that the oil companies would continue to be notified through the PAW of surplus petroleum fixed installations in other world areas as they became available.

Colonel Gruneck in his remarks stressed the fact that this type of meeting in no way voided the established FLC procedure that all business must be conducted through the FLC overseas field commissioner where the surplus is located. All negotiations and sales must be completed through contact with the field commissioners, Colonel Gruneck stated.

The meeting also proved valuable in that it brought out many general questions of overseas surplus disposal in which the petroleum industry was interested.

Participating in the discussions were the following representatives of other interested government agencies:

David A. Robertson, State Department and Petroleum Facilities Coordinating Committee; E. B. Swanson, Petroleum Administration for War; Brig. Gen. Howard L. Peckham, Quartermaster Corps, Army; Commander R. B. Nelson, Navy, and A. Eric Taff, Surplus Property Administration.

Robertson discussed at length American foreign policy as it applied to the petroleum industry.

● **OIL TREATY HEARING JANUARY 16.** The Senate foreign relations committee has set a hearing for January 16 on the Anglo-American petroleum agreement, Chairman Tom Connally of Texas announced. All interested persons will be given an opportunity to testify, Senator Connally said. Opposition to the treaty has been voiced by some Texas oilmen and members of the Texas Railroad Commission.

● **NEED FOR NEW DRILLING STRESSED.** New oil tests must be drilled in the United States in "dynamic exploration" if peace-time demands are to be met with domestic petroleum, a Senate oil investigating committee was told recently by Ralph K. Davies, Deputy Petroleum Administrator for War.

"Unless we are to curtail our use of oil or radically increase imports or resort to higher-priced sources of production, including synthetics, we must reverse the downward trend of discovery," Davies said.

For four years before we entered the war, he said, the United States was not discovering oil as fast as it was being used.

Present estimates, he stated, indicate the 1946 demand for oil and its products will be higher than that of 1942 and 1943.

In addition to stimulating discoveries of new oil, he told the committee, the nation should be vigilant not to waste petroleum. He said California, Illinois, Montana, Wyoming and Colorado should have oil conservation statutes like those of eight other states—Arkansas, Alabama, Louisiana, Texas, New Mexico, Oklahoma, Kansas, and Michigan.

Davies suggested that anti-trust laws be amended to exempt oil operators who wish to join in voluntary conservation programs.

Howard W. Page, director of the PAW program division, testified that by mid-1946 the world-wide crude production will fall below peak levels of 1944 by 800,000 bbl. daily, but will be higher than in 1942 and 1943. The change will be almost entirely in this country, he said.

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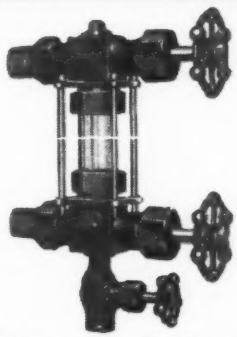

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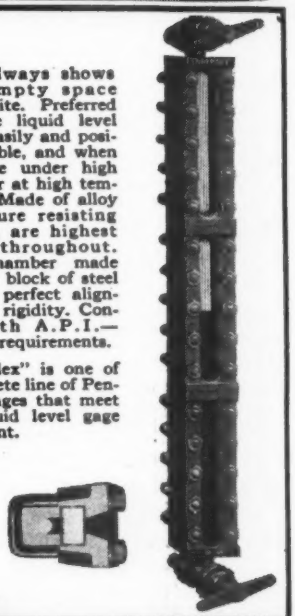

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MAJOR *Oil Field* ACTIVITIES

● **NORTH CAROLINA.** For the first time North Carolina will be tested for oil. A 35,000 ft. wildcat well will be started by April 1, 1946 by W. W. Connell of Longview in Hertford County, North Carolina. The wildcat will be the Connell No. 1 W. H. Bashright. Also in North Carolina the Standard Oil Company of New Jersey has spudded its wildcat on Cape Hatteras. It is scheduled to go to 8500 ft. and is being drilled on state tideland.

● **OKLAHOMA.** Deep Rock Oil Corporation, Burke-Greis Oil Corporation, and Mid-Continent Petroleum Corporation have opened a new Wilcox pool near the old Billings field, Noble County. The discovery well, White No. 1, SW NE NE 19 2 -2w, flowed 462 bbl. of oil in 11½ hr. from a depth of 4433 to 4450 ft.

The state's newest producing area is the Parkland oil pool in northeastern Lincoln county. R. L. Kemp and associates well, Mary J. Brown No. 1, a wildcat in SW NW SE 20-16 5e, which was a failure at 4022 ft. in dry Mississippi lime, has found production in a Prue sand. The test was plugged back to 3485 ft. and made 5 to 10 bbl. an hr. of 45-gravity oil along with an estimated 5,000,000 ft. of wet gas.

● **KANSAS.** A new pool was opened in the Sunflower state by E. Paul Hatfield, Wichita, and Summit Drilling Company, Tulsa, with Bellman No. 1, NE NE SW 15-30n-1e, wildcat test in the northeast part of Sumner County. The test turned out to be an oil producer after once being called a dry hole. It was drilled to total depth of 3916 ft. and flowed 335 bbl. of oil in a 48-hr. test.

A new petroleum-producing horizon has been discovered by Lion Oil Company with completion of its Andrews No. 3 well in the Coates pool, Pratt County, Kansas. The well was said to be producing a total of 38 bbl. an hour.

A new pool or a long extension to the Merten pool has been given to Barton County, Kansas, by the Phil Hon Oil Company. The well is the Mauler No. 1, SW SW SW 36-18 15w. It has an initial rating of 100 bbl. daily from the Arbuckle at 3515-68 ft.

The Beech Aircraft Corporation's first oil strike is the No. 1 McLean, in the NW-SE NW 1-27-1e in Sedgwick County, Kansas. The well is estimated by company officials to be good for 75 bbl. of oil daily and is bottomed at 2979 ft.

A new helium gas pool has been opened in Rush County, Kansas, by El Dorado Refining Company and associates with the Urban No. 1, a wildcat in the NW NE NW 21 16 17w, seven miles northwest of the Albert-Otis gas area. The Urban has the Arbuckle at 3521 ft. and total depth is 3548 ft. It gaged 1,300,000 cu. ft. of gas daily.

● **NEW MEXICO.** Drilling is due to start at once on a deep wildcat in New Mexico. Southern Union Gas No. 1 Lucas, 5-2n-30e, is an 8000 ft. well in the Panhandle section of extreme Northwest Roosevelt County.

● **TEXAS.** W. R. Skeen and associates have made a new Ellenburger oil discovery for Stephens County. The well is the R. Hatchett No. 1 block 33, Orphan Asylum land, 14 miles southwest of Breckenridge. The discovery was estimated flowing at the rate of 20 bbl. of fluid an hour and its total depth is 4228 ft.

Stephens County apparently has a new pool opened by Blake No. 1, SW NW SE 21-2 8w, drilled by The Texas Company. It had 360 ft. of high gravity oil and 270 ft. of oily mud. The well has a total depth of 6879 ft.

Starr County has a new oil pool with the opening of W. H. Holland No. 1 M. M. Garcia, block 16, survey 917. Perforations are from 3498 to 3512 ft. It averaged an estimated 125 bbl. daily.

Tests at the Continental Oil Company No. 1-F Slick Estate, survey 539, indicated a new oil field discovery for Starr County. After perforating in sand at 4183-89 ft. the well flowed 52 bbl. of oil daily.

James M. Manning No. 1 Adair, northwest of Woodson, in Throckmorton County, block 961, T. E. and L. survey opened a new Caddo Pool. Top of the lime was at 3893 ft. and saturated formation was at 3905 ft. The well showed gas in 7 minutes and in 15 minutes flowed oil.

There is promise of a new Caddo pool as a result of Continental Oil Company's new well southwest of Buffalo Springs, Clay County, S. W. Heard No. 1, block 3222 T. E. & L. Survey. From a depth of 5738-81 ft. a recovery of 1450 ft. of pipe line oil was made in 10 minutes.

An important oil discovery made in Crane County, West Texas, has been announced by Atlantic Refining Company. According to the company this well is a dual discovery in both Devonian and Ellenburger formations. In initial tests the well produced at a daily rate of 1430 bbl. from the Devonian and 1344 bbl. from the Ellenburger.

In Hardin County Pan American Production Company has opened a new pool with the No. 1 Olive Sternberger Lumber Company, P. S. Watts survey. Drilled to 10,049 ft. it flowed a potential of 596 bbl. of 44.5 gravity oil.

At Quitman field, Shell No. 1 Atlatl-Harris, Goodsir survey, pumped 100.2 bbl. of 23-gravity oil in 20.5 hr. from 4155 ft. in the sub-Clarksville. It opens shallow pay in the Quitman field, which produces from the Paluxy.

E. Cockrell has opened a new oil pool in Brazoria County. The well, E. Cockrell No. 3 Seaburn Estate, is situated 11 miles southwest of Angleton. Drilled to 3970 ft. the well flowed a potential of 231.84 bbl. of 25.40 gravity oil daily.

L. T. Burns of Wichita Falls and his drilling crews battled for 36 hours to bring his No. 1 Kunkel, North Texas wild gusher, under control. The well is indicated as one of the largest wells ever drilled in North Texas. It is bottomed at 4899 ft. and flowed at an estimated rate of 1000 bbl. of oil an hour.

It was indicated that the Humble No. 1 Mrs. Hermie H. Davis wildcat, Dimmit County, 3½ miles southwest of Carrizo Springs, would make a big gas well. It was drilled to 2710-17 ft. and is situated in Lot 6, Block 1, of Subdivision of T. and N. O. survey No. 15.

A second Devonian lime pool has been opened by Mid-Continent Petroleum Corporation in southern Andrews County. The well is University of Texas No. 1-15 in 42-13, University lands, south of the Fullerton pool. It has a daily potential of 1427 bbl and was drilled to a depth of 8590 ft.

A new Bryson sand pool was opened 9 miles northeast of Graham in Young County. Fred M. Manning No. 1 M. K. Graham estate wildcat gaged 100 bbl. daily from 3075-90 ft. Evidencing the interest aroused over the discovery, two new locations have been staked in that area by Robertson Drilling Company and Reno Oil and C. M. Morrison.

● **COLORADO.** The first 1000 bbl. well for the Rangely field, in Rio Blanco county, Colorado is Texas Company's No. 3-34 U-P, SW NW 34-2n 102w. It was drilled to total depth of 6404 ft. and flowed 950 bbl. of oil per day on early tests. Later reports said the well was making more than 1000 bbl. daily.

● **CALIFORNIA.** Richfield Oil Corporation has reported possibility of a major oil discovery in the Los Angeles area. This report followed a highly-favorable test at its Union Pacific No. 1 well in the Bandini region. Results of a three hour test showed a rate of flow of 754 bbl. net of 32 gravity oil. The depth of the well is 8608 ft.

● **LOUISIANA.** Union Sulphur Oil Company has a new oil field in Coastal Louisiana. The discovery is Bordages No. 1, 5-10s-9e, Calcasieu Parish. On initial gage it flowed 60.72 bbl. from 8480 90 ft.

● **BRITISH WEST INDIES.** Several leading oil groups have sent representatives to the Bahamas, British West Indies and organized local corporations, according to the British press. No wells have been sunk, but visiting experts are said to be favorably impressed.

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MAJOR *Pipe Line* ACTIVITIES

● **INCREASE LINE VOLUME.** Federal Power Commission has granted authority to United Gas Pipe Line Company to transport a maximum of 172,000,000 cu. ft. of natural gas per day from Carthage, Texas, gas field to the Monroe, Louisiana, field to serve its present customers, the Memphis Natural Gas Company, Southern Natural Gas Company, and Mississippi River Fuel Corporation, and also to the United Gas Corporation for resale in Calhoun, Louisiana.

The authority was through a modification and amendment of an original certificate issued last July 5, by which 114,000,000 cu. ft. per day was authorized for transportation by United for the Tennessee Gas and Transmission Company over the Carthage-Sterlington pipe line.

● **SHORT LINE COMPLETED.** A new 17-mile pipe line connectiing the McBride refinery at McAllen, Texas, with the main line of the Continental Pipe Line Company, leading from the Rincon field to tidewater at Port Isabel now has crude oil flowing through it. The line has a capacity of 2400 bbl. daily.

● **APPLIES FOR 95-MILE EXTENSION.** The Tennessee Gas and Transmission Company has made application to the Federal Power Commission to construct a 95 mile pipe line extension in Texas, which they consider is necessary to afford continuity of service to the Appalachian region. The application is to build and operate a 16 in. line from the San Salvador field in Hidalgo County, northeastward to a connection with Tennessee's main line in Nueces County. The estimated cost including a dehydration plant to be operated in connection with the line is $2,260,000. In addition, the company wants to build 2,380 ft. of 8 in. pipe line south from the main line in Harris County to connect with United Gas Pipe Line Company's 10-in. Katy-Satsuma line in the same county.

● **"BIG" LINES DISCUSSED.** Seven oil industry executives concurred in the opinion that the "Big Inch" and "Little Inch" pipe lines should no longer be used to transport oil but should be held in reserve as a military asset unless utilized for natural gas movement. This was told to a senate committee in Washington. Sidney A. Swensrud, vice president of the Standard Oil Company of Ohio, and Holley Poe, New York, do not think that the two lines, built as war facilities, will fit into peace time economy because movement by tanker and existing private lines is more economical. Poe said the lines "under certain conditions," could be used for natural gas service.

D. Harold Byrd of Dallas headed a group of Texas oil men who seek to buy the "Big Inch" and "Little Inch" pipe lines. They would acquire the lines for use in transporting natural gas from Texas to the east. They awaited their turn at the hearing to testify. The pipe lines would be bought by the "Independent Petroleum Cooperative Association." It was incorporated in Texas by E. B. Germany, L. M. Glasco, and W. L. Pickens.

● **PLUTO DISMANTLED.** "Pluto"—the secret underground oil pipe line is being dismantled. This is the line that pumped millions of gallons of gasoline across the channel for the Allied forces. Army engineers are digging up thousands of buried pipes and storage tanks that were hidden with the greatest of secrecy in bungalows and other buildings are being brought from their hiding places. All this installation work was done at night so that no trace of what was taking place would be discovered by prying German camera eyes.

● **CARRIERS FOR NEW PRODUCTION.** As a sequel to the development of important sweet crude reserves and entry of new crude buyers, pipe line construction in West Texas has increased to substantial proportions. The pipe line division of Gulf Refining Company is at work providing facilities to absorb all the premium quality sweet crude produced in the Keystone-Ellenburger field, Winkler County. A second 62 mile 8-in. carrier from this field to its Midland terminal and tank farm is near completion and work has just been started on 8 mile of 10 in. loop on its Winkler-Ward County unit into Midland. Miscellaneous loops and new units between Midland and Port Arthur will involve 369 mile of 10-in, 44 mile of 12-in. and 6 mile of 14-in. Upon completion the company will have facilities for handling of 108,000 bbl. daily out of Midland. The Permian Basin system of the Shell Pipe Line Corporation is being materially expanded to take care of the prolific sweet oil areas opened by Shell Oil Company.

The following work is under way: In the TXL and Wheeler fields, 27 mile of 8-in., parallel to a 6-in. via the Monahans field, Ward County, to connect with its Wink-McCamey multi-unit carrier; a 21-mile 8-in. extension from its Wheeler field station thence northwest to the prolific Ratliff-Bedford dual pay discovery in Southwestern Andrews County.

Shell Pipe Line Corporation is also building a 9.7-mile 6-in. lateral from its Monohans-McCamey system at a point in South Central Crane County thence northeast to Crane station on Texas-New Mexico Pipe Line Company. This unit will handle 4500 bbl. daily of sweet crude contracted by Cities Service Oil Company for one year.

● **WORK PROGRESSING.** Work on several projects has been reported by Williams Brothers of Tulsa, pipe line contractors. Work is in progress at Fort Madison, Iowa, where a 16-in. crude oil line is being laid at a river crossing. Near Lawrenceburg, Ohio, contractors are laying a 7-in. crude oil line across the Ohio river for The Ohio Oil Company, while two 8-in. products lines are being laid at a river crossing north of Blair, Nebraska, for Great Lakes Pipe Line Company. Contractors are also laying 56 mile of 8-in. natural gas line for the Great Lakes firm north of Omaha, Nebraska.

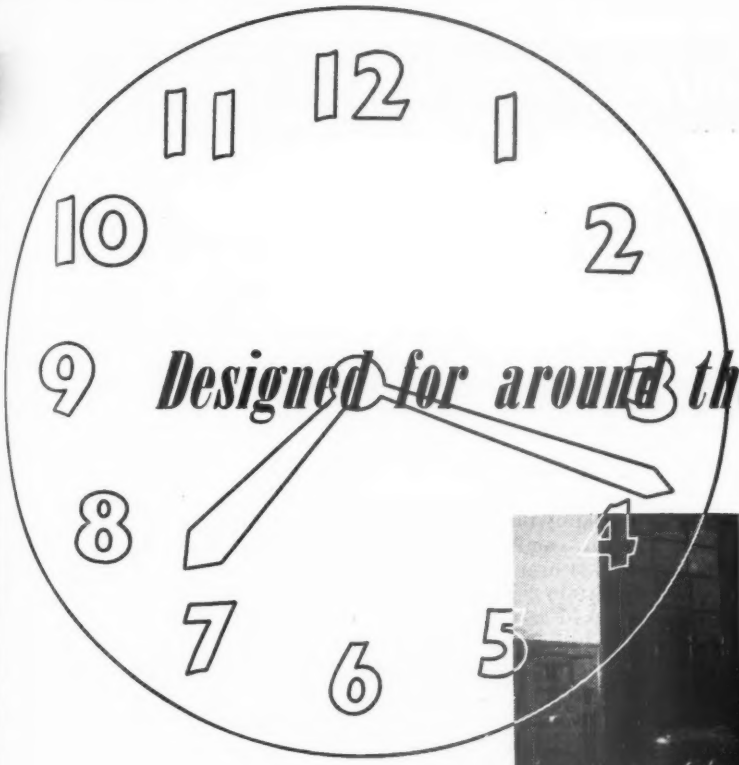
● **TO LAY GATHERING LINE.** Interstate Oil Pipe Line Company, Tulsa, plans to extend service to the Mattoon oil field, southwest of Mattoon, in southern Illinois by a pipe line connection. The intention of laying 19 miles of 6-in. line connecting the field with the Montrose pumping station on the Ohio Oil Company's main line south of Mattoon was announced by L. F. Kahle, Interstate executive vice president, and Bruce Ramsey, vice president in charge of the northern division. Initial survey is under way. Currently the Mattoon production is being moved by truck and tank car.

● **BUILDING CARRIER TO TERMINAL.** Sun Pipe Line Company has awarded a contract to J. R. Horrigan Construction Company for laying a trunk line that will extend from several southwest Texas pools, already linked by gathering systems, to a tanker terminal at Harbor City, near Corpus Christi. Work started in December on this project, which calls for 84 mile of 10-in. pipe from the Seeligson pool near Premont at Aransas Pass and 34 mile of 8-in. pipe from the Kelsey-Bass field in Brooks County to the Sullivan-Mariposa area in Jim Wells County.

● **LONGEST LINE IS SURPLUS.** The future of the world's longest pipe line is uncertain. Col. W. C. Kinsolving, of Beaumont, Texas, who was in charge of building the 2500 mile line from India to China, said that the line might be traded or even given to the British. When American troops are gone, the upkeep of the project will be impossible, and as the matter now stands, the project has no commercial value.

● **RANGELY PIPE LINE.** A pipe line constructed and designed by the Stanolind Pipe Line Company, acting as agent for Utah Oil Refining Company, has helped to develop the long dormant Rangely oil field in the past few months. It is now one of the most active and interesting oil fields in the United States.

The 10 in. line from Rangely to Wamsutter, Wyoming, a distance of 148 miles, was started on July 15 and completed September 19 and crude was first delivered at Wamsutter October 3. At Wamsutter it is delivered into the main 8-in. line of Utah Oil Refining Company, which extends from Fort Laramie, Wyoming, to Salt Lake City, a distance of 442 miles. The Rangely line is designed for a maximum operating pressure of 15,000 lb. with a daily capacity of 20,600 bbl. at that pressure, with one pumping station.



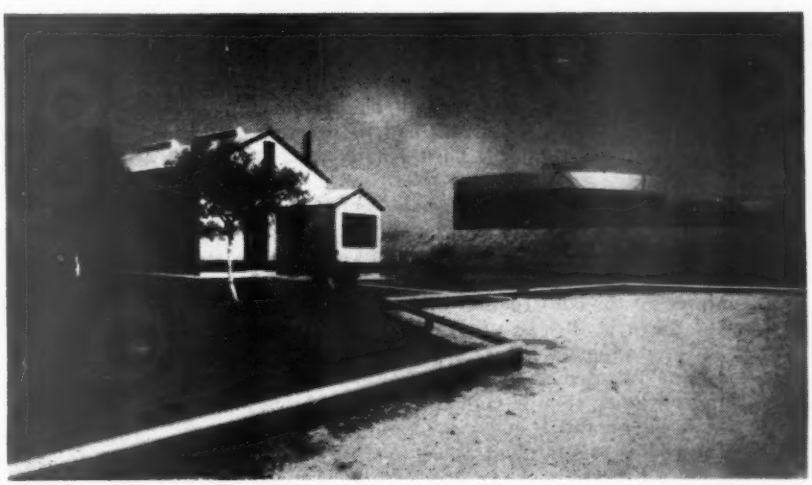
Designed for around the clock operation

The centrifugal pump is driven by a Westinghouse gear speed increaser. Both are mounted on a common bed plate to preserve alignment.

THE *extra* precision in Baldwin Diesel Engines pays especially big dividends in the isolated pumping stations where the "tricks" are 24 hours long, and there's no stand-by equipment.

The pioneer diesel-powered pipe line in this country was equipped with Baldwin Diesels, and today hundreds of installations all over the nation depend on the same reliable equipment. The illustrations show a typical application . . . a 6-cylinder Baldwin driving a centrifugal pump through step-up gears.

Baldwin Diesels for pipe line service are available from 465 to 760 b.hp., over a speed range from 300 to 450 r.p.m., in stationary, portable, and semi-portable types. Ask for detailed information. The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Philadelphia, New York, Chicago, Washington, Boston, Cleveland, St. Louis, San Francisco, Houston, Pittsburgh, Detroit.



A typical modern pumping station.

BALDWIN

DIESEL ENGINES

BLW THE BALDWIN GROUP

4903

MAJOR *Refining* ACTIVITIES

● **SKELLY EXPANDS KANSAS PLANT.** New facilities are being installed by Skelly Oil Company at its El Dorado, Kansas, refinery. The units will make possible recovery of light petroleum fractions formerly burned as refinery fuel, and further processing into liquefied petroleum fractions, polymer gasoline and motor gasoline. Need of these units stems from the current trend in refining toward production of more light hydrocarbons and toward greater demand for light ends produced.

An increase of 1200 bbl. a day of commercial propane and motor fuel, including polymer gasoline, is expected to result from the installation of these new facilities. It should be completed late in April, 1946.

● **WARREN PLANS NEW GASOLINE PLANT.** The construction of a $2,000,000 natural gasoline plant will begin immediately by The Warren Petroleum Corporation of Tulsa, Oklahoma. This plant will be situated three miles south of Holliday, Texas, in Archer county. It will have a capacity of 10,000,000 cu. ft. of gas daily.

● **GERMAN.** In a speech prepared for the 66th annual meeting of the American Society of Mechanical Engineers, Dr. W. C. Schroeder, chief of the office of synthetic liquid fuels of the Bureau of Mines, said that Allied wartime bombings virtually destroyed all German fuel oil plants. The Germans tried to develop the oil industry underground but at the close of the European war only two plants were found in an operating state.

● **SYNTHETIC OIL PLANTS.** The Missouri Ordnance Works, near Louisiana, Missouri, will be taken over by the Bureau of Mines and converted into a demonstration plant for the production of gasoline and oil from coal and lignite it was announced by Secretary of the Interior Harold L. Ickes. This will speed up the Federal synthetic liquid fuels research and demonstration program. The plant is within access of the major coal fields of the United States and was chosen after a nation-wide survey in which 206 proposed locations in 21 coal-producing states were carefully considered.

Two processes now in use for converting coal or lignite to liquid fuels will be adapted to American raw materials at Bruceton and Louisiana. The first, a direct hydrogenation process, is employed in both Germany and England. The second process is the indirect gas synthesis, which has had its greatest application in Germany. Each unit will have a daily capacity of 200 bbl. of oil.

Synthetic fuels from coal and oil shale cannot compete with natural petroleum anywhere under current prices. Most important, the U. S. will have the "know how" of synthetic fuels and the facilities for producing them.

The contract for the construction work to complete the major buildings of the new Bureau of Mines synthetic liquid fuels research and development laboratory near Bruceton, Pennsylvania, has been awarded to the Navarro Corporation of Pittsburgh, Pennsylvania, it was announced. The laboratory at Bruceton will be operated in conjunction with the synthetic liquid fuel demonstration plant to be established near Louisiana, Missouri. Process improvements developed in the laboratory will be tested on a commercial scale in the demonstration plant, thus providing a blue-print for the development of a synthetic liquid fuels industry by private enterprise.

● **GIVE CATALYST NEW SHAPE.** Scientists at Standard Oil of Indiana borrowed a nineteen-story elevator shaft in their company's general office for an experiment. They were trying to shape particles of a new oil-cracking catalyst like tiny baseballs instead of like miniature doughnuts. By doing this a saving in the future cost of gasoline-production could be effected because doughnut-shaped particles of catalyst crush and wear away to dust more rapidly than spherical particles would. Previously the catalyst particles were found to be shaped like tiny rings as a result of an experiment in which they were dropped through a tower during formation. The scientists hit upon the idea that if they were dropped through a taller tower it might change them to the desired spherical shape. No tall tower being available at the Standard Oil research laboratory they used the elevator shaft in the Chicago building. With a spray gun they dispersed the catalyst solution in the top of the shaft while the door was held open. To collect the particles, they put a box on the top of the elevator, down on the ground floor. The particles were taken to a microscope and examined and found to be perfect spheres. The scientists considered this unusual experiment to be highly successful.

● **ASCERTAIN FUEL BURNING RATE.** A report on the domestic fuel test program instituted in July, 1944, has just been issued by the Western Petroleum Refiners Association. The program, conducted with aid from other organizations, has extended over 18 months. The research and test program was to ascertain burning characteristics of various thermal, catalytic cracked and straight run fuels, when used as domestic heating oils in pot-type wall vaporizing burners.

Fuel for this equipment has been straight-run prime white distillate and in the boiling range of No. 1 heating oil. The supply of No. 1 prime white distillate will be insufficient since more consumers are using vaporizing burners. The report voices the general opinion that availability of fuel for these burners may be increased sufficiently to meet demand by adding and using certain intermediate stocks. An increase in supply may be obtained by substitution of No. 2 straight-run distillate or by substitution or addition of limited quantities of cracked intermediates. It was stated any of the usual intermediates, which may be substituted for No. 1 white distillate, will unfavorably affect performance of the vaporizing pot-type burner, and that extent of this effect may or may not be within range of acceptability by consumer.

● **TO REBUILD GASOLINE PLANT.** Abasand Oils, Ltd., separation plant at Fort McMurray, Alberta, Canada, which was damaged by a $300,000 fire in June, will be rebuilt this year, it is reported. The Dominion government is withdrawing its interest in the development so the plant will be operated by private capital.

● **RETURN PLANTS TO PRIVATE OPERATION.** The Navy has relinquished possession, control, and operation of three Ohio oil refining plants: Standard Oil Company of Ohio, at Lima; the Canton Refining division of Central Pipe Line Company, Canton, and Sun Oil Company plant at Toledo. These plants, along with 50 other oil refineries, were seized by the Navy at the direction of the President over a month ago because of labor disputes. The management of the three companies presented the Navy with a petition which stated that there were no labor disputes involving the plants.

● **TO GET ALL SYNTHETIC RUBBER FROM OIL.** Wartime plants that made synthetic rubber from alcohol are being closed because the country can get from oil all the synthetic rubber it needs.

G. R. Hadlock, associate director of the Office of Rubber Reserve, told reporters that the reason for abandoning alcohol in favor of petroleum as a butadiene source, "is purely dollars and cents." Farm state congressmen and agriculture groups urged the alcohol project to promote the use of grain. Short of government subsidies, however, there appears no way to make the alcohol plants economically feasible.

● **ORGANIZE AUSTRALIAN REFINERY.** The California Texas Oil Company is forming a new oil refining company in Australia. The Australian government has approved the formation of the company on the condition that 60 per cent of the shareholders are Australian.

David Craig, prospective managing director of the new company—Bitumen and Australian Oil Refineries, Ltd.—said the firm's activities might make Australia self-supporting in lubricating oils and bitumen within the next two years.

THE Petroleum Engineer

DECEMBER, 1945

PLAYA DEL REY OIL FIELD SOLVES GAS STORAGE PROBLEM FOR LOS ANGELES AREA

By **RICHARD SNEDDON,** *Pacific Coast Editor*

EXCLUSIVE

To supply a swiftly mounting demand for war plants, an underground gas storage plan was executed.

In a large populous area such as that of which Los Angeles is the center, the demand for gas fuel, even in peace times, is subject to substantial and sometimes sudden fluctuation. Partly this changing need is seasonal and, therefore, to a certain extent predictable. The winter demand, for example, is much greater than that of the summer, for quite obvious reasons; but a quite sizeable proportion of the total demand is created by emergency conditions that cannot be foreseen. Thus, it is difficult under normal conditions to project advance estimates covering the quantity of gas, the operational facilities, and the storage capacity required to assure an adequate supply at all times to industrial and household consumers.

If the problem is admittedly serious in ordinary times, it is easy to concede that under war conditions it may become infinitely more complex, for then great materiel manufacturing plants spring up with abandon, pyramiding the full demand to prodigious and quite unpredictable dimensions, correspondingly increasing the need for equipment and machines that are in highly critical categories and, therefore, practically unavailable. Indeed, when considered from the standpoint of vulnerability, material availability, expeditious installation, and overall cost, the construction of aboveground tankage and facilities for an indeterminate period is distinctly a precarious undertaking.

Nevertheless, that is the sort of situation with which Southern California was faced in the middle of 1942. By this time the war had developed into a production race and the maintenance of an uninterrupted supply of diversified products in ever-increasing amounts to the armed forces had become critically important. Many plants had been swiftly enlarged, tooled, and generally adapted to the manufacture of highly essential items. Others were in the process of modification or construction, and it was obvious to all the experts in such matters that if these plants were to perform their respective ultimate functions in the grand scheme, something would have to be done about the natural gas situation. Steel tankage was out of the question because steel just wasn't available, and in certain quarters some very profound thinking was done on the matter.

It would be difficult, and after all it is perhaps unnecessary, to say who first broached the possibility of utilizing a depleted oil reservoir for the storage of natural gas, but certainly the idea seemed at once to offer a ready solution to several very perplexing aspects of the storage problem. In any case, the first significant move in the matter was the preparation of a report to the California Railroad Commission by its consultant, John F. Dodge, and Roy A. Wehe, gas and electric engineer, which urged quick action to meet the sharply increasing war requirement of natural gas in the Los Angeles area. It pointed out that each new demand, and they were coming dangerously often, served to exaggerate a condition that already was jeopardizing the production of war essentials.

The report suggested the Playa del Rey oil field at Venice as an ideal site for the institution of an underground gas storage project, and propounded the reasons for this recommendation, at the same time detailing facilities that would be required, and the estimated cost of adaptation and operation. Professor Dodge was responsible for the development of the overall plan of operation and Wehe for the cost estimates. After a full discussion by representatives of Pacific Lighting Corporation, Union Oil

Company, Office of the Petroleum Coordinator, U. S. Army Utilities Division, State Department of Natural Resources, and the Railroad Commission, concurrence was reached on the following considerations and recommendations:

Increased vital demands of war interests in Southern California were precipitating a critical need in the Los Angeles base area for substantial additional gas during the winter season. The proposed storage project would provide a part of this additional requirement.

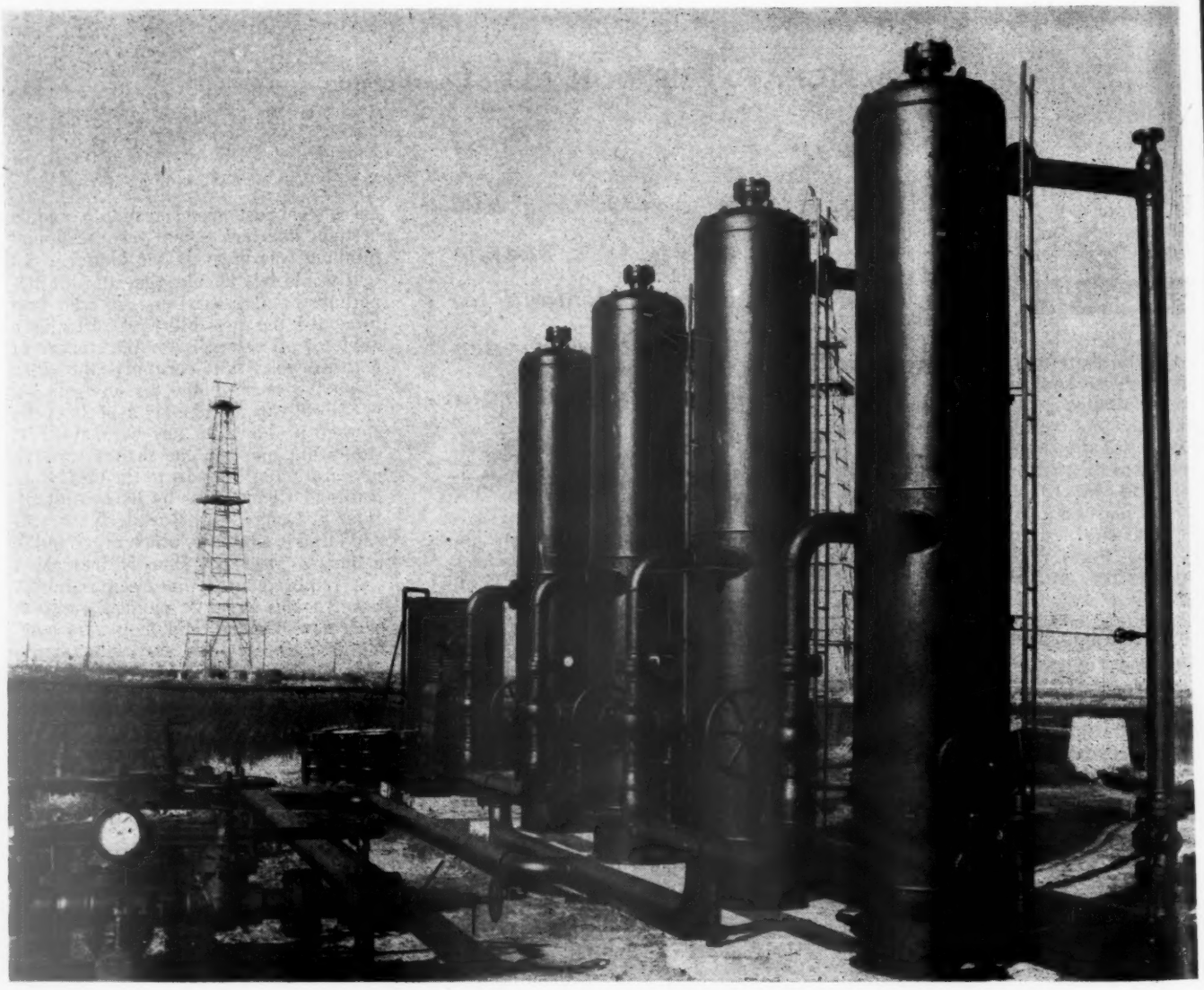
The geological structure of the field was favorable to the storage of gas and the field was suitably located.

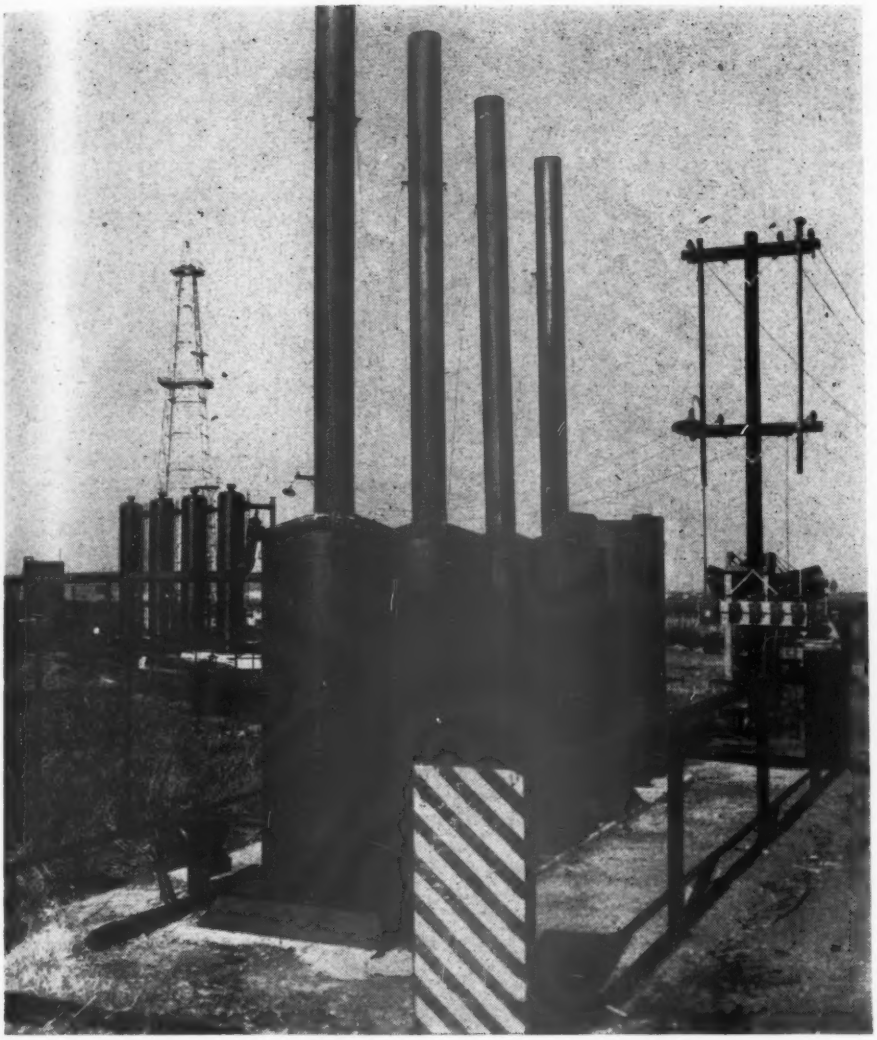
Estimated costs of operating such storage appeared to fall within economic limits.

As unified control of the field was

Lew Kelsey, production foreman of Union Oil Company, Charles Pryor, plant foreman of Southern California Gas Company, and Otto Gillingham, assistant production foreman of Union Oil Company, discuss their joint interests in gas storage.

The battery of traps below is a recent installation and was not part of the original layout. The 480-lb. traps are used to separate oil and water from gas.





The lines and fittings are jacketed in places where pressure changes are likely to cause freezing of valves or constricted flow lines. Hot water for these exchangers is supplied from the battery of hot water heaters shown.

deemed essential to satisfactory operation, and as no local or state agency had the authority to condemn the property, it was agreed that possession of the field must be effectuated by the National Government through a properly designated agency that would either operate the project or designate in what manner it must be operated.

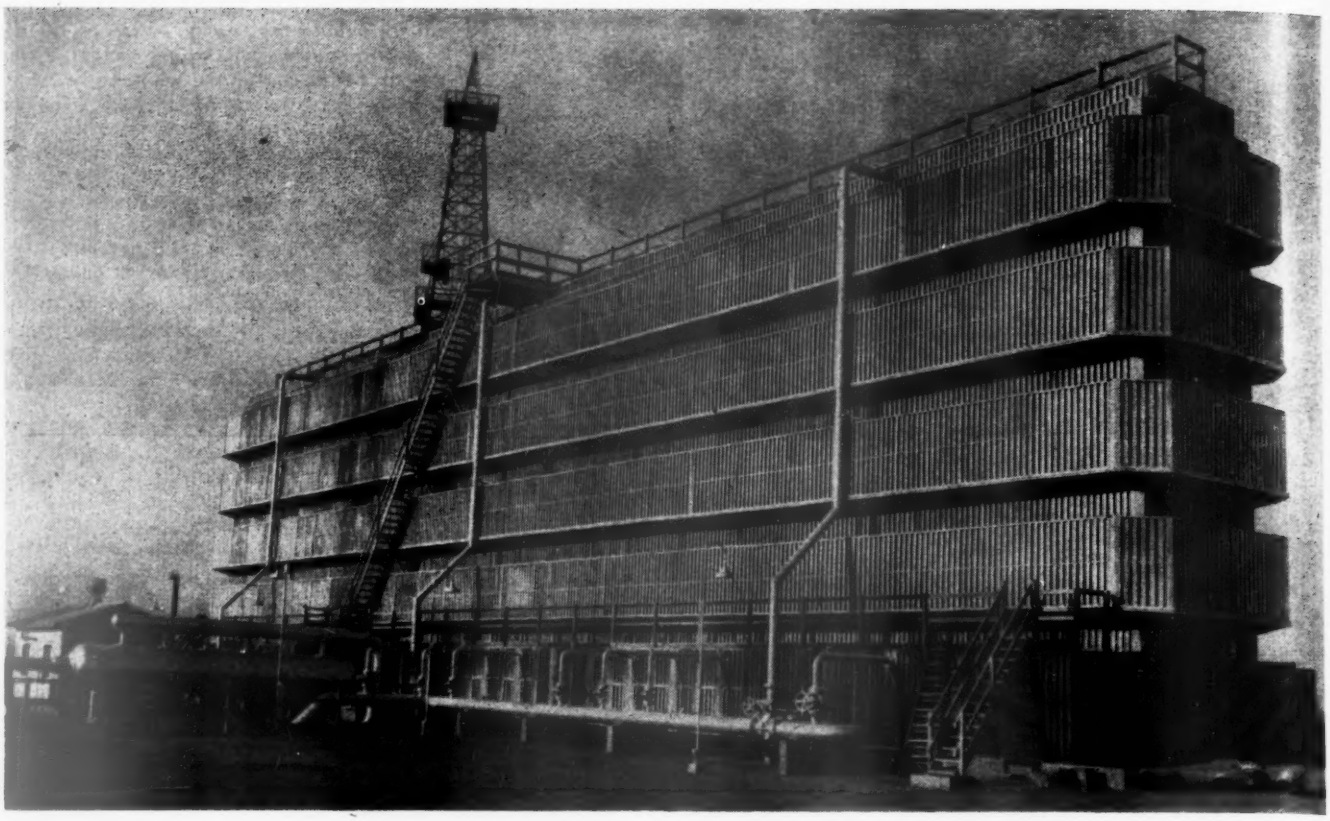
With these areas of agreement established, Southern California Gas Company was designated as the logical choice to install and operate the necessary gas facilities for injection and withdrawal of gas, and Union Oil Company, thoroughly familiar with the history, substructure, and general characteristics of the field, was the equally logical choice to take over the responsibility of keeping the wells in shape and supervising and directing field activities. So while condemnation proceedings were instituted by the Government to obtain control of the field, the Defense Plant Corporation was authorized to go ahead with the project, with Southern California Gas Company and Union Oil Company playing the respective roles already defined.

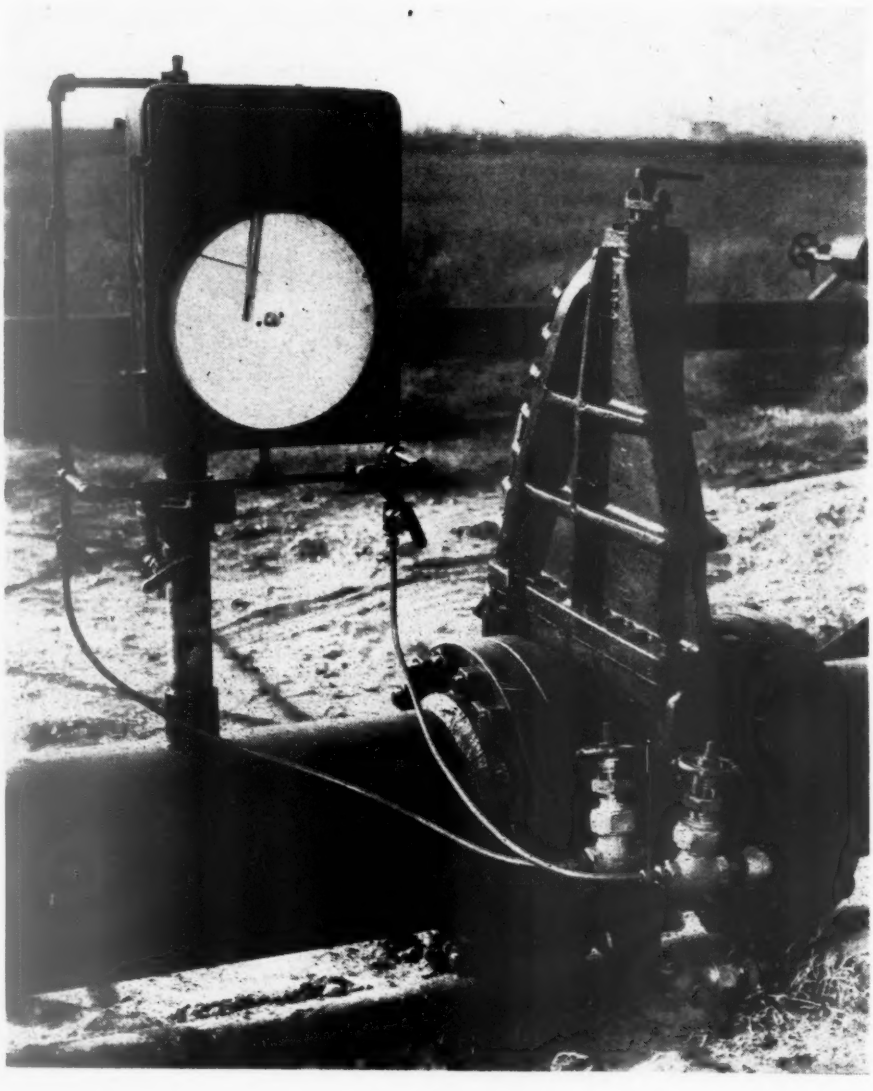
It should perhaps be emphasized that natural gas was the principal fuel of the war plants and surveys of requirement in the Los Angeles and San Diego areas had indicated that peak 24-hr. winter demand under the prevailing system of operation would be greater than 24-hr. production. It was obvious then that unless something could be done to change the situation, vital industrial plants would sooner or later have to be shut down.

Gas companies had been unable to increase supply by building new transmission lines, installing extra compressor capacity or additional steel storage, because such moves called for large quantities of high priority materials that were virtually unobtainable and definitely not obtainable with any degree of celerity. Underground storage in a closed structure offered many immediately obvious advantages. It eliminated the need for the critical materials mentioned, dissipated the vulnerability weakness (bombing by the enemy was not a too remote prospect in 1942), finally, it made available very large capacity storage almost at once. The actual usable capacity in the Del Rey field was estimated at approximately two billion cubic feet, many times what was actually available in steel storage above ground.

Other important considerations cited in favor of underground storage were that it promotes gas conservation, and to a lesser extent perhaps, tends to increase the ultimate oil yield from the wells. In the off-heating season gas pro-

Otto Gillingham of Union Oil Company is here adjusting the flow bean on the air injection well. The injection line is the one in the forefront.





Cooling tower at Southern California Gas Company's compressor plant, showing scrubber and pump house. (Above.) At left is a gas measurement fitting and an orifice meter at one measuring station.

duction is normally at its peak and in the past for lack of storage, it has been necessary sometimes to blow it to the air and sometimes to feed it to adjacent industrial plants in which a less vital type of fuel might have been used satisfactorily.

Then again at the time the project was being discussed, plans were under way to convert at least one standby plant to the manufacture of butadiene, which was expected to release sizeable quantities of by-product gas. This could be used during heavy demand periods but in summer would simply be lost unless additional storage could be made available.

The Playa del Rey field is located on the Pacific shore, approximately 2 miles southeast of the beach community of Venice, which in turn is a part of the City of Los Angeles. The established producing area is divided by a property line that also divides two Spanish land grants — La Ballona and Sausal Redondo. Part of it lies in the city and part in the County of Los Angeles. There was a time when the Del Rey Hills and the Ocean Front were believed to represent a geologic and structural unit but about 1935 they were recognized as separate and distinct—the Del Rey Hills portion of the field having a proved productive area of about 310 acres, divided between the hills and the tideland marshes to the northwest.

Geologically, the oldest formation pen

etrated by the wells is of metamorphic origin and is known as the Schist. The Schist body in the region is constituted of a long ridge with a northwest-southeast trend, and forms the structural core on the flanks and over the crest of which the oil-bearing and other sedimentary rocks have been deposited. The next oldest stratigraphic unit and chief oil producing formation is known as the Conglomerate or oil sand and is actually a partially stratified mixture of both in varying proportions.

UNLIKE most of the California fields, Del Rey appears to have no actually encroaching edge water and when upper waters from fractures in nodular shale are excluded there has been little difficulty with water incursion. Tests show depletion is almost entirely of gas expansion type and it is, therefore, believed that reservoir sands originally containing oil and gas remain currently free from water flooding.

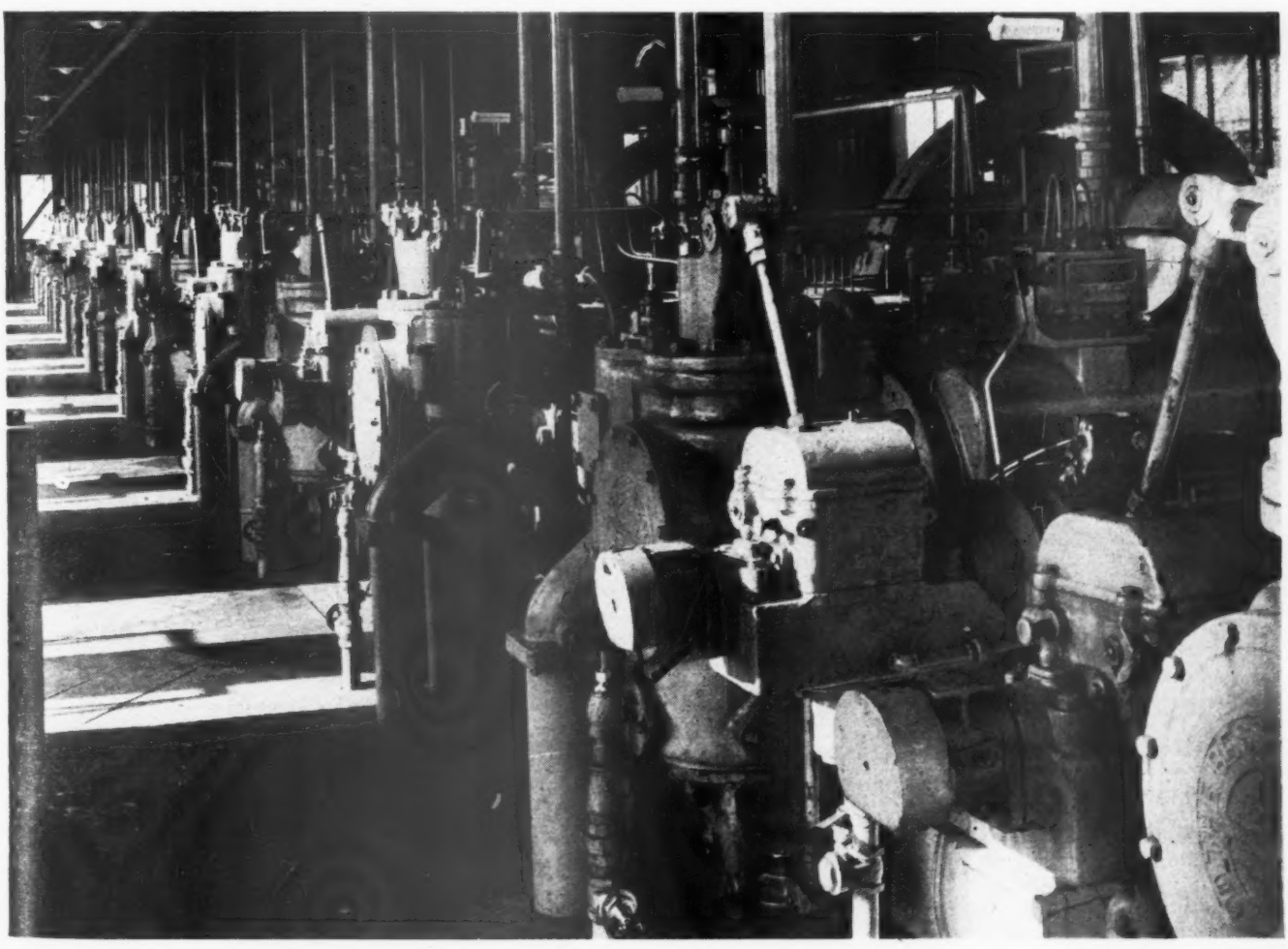
In studying the adaptability of the field for a gas storage project, original logs of the wells were used and a new isopach map of production sand thicknesses was drafted. From this it was concluded that the formation was ideal for the purpose and that storage capacity would be, as already indicated, in the neighborhood of 2 billion cubic feet. Actually it was half again this much, but the 2 billion figure was taken as the volume of gas that could be stored and withdrawn under the pressure conditions that would need to be maintained in the operation of the project.

Before work was begun on the field installations, the Southern California Gas Company conducted a pilot plant investigation to be sure that gas could be injected into the formation. Meantime, toward the end of 1942 and during the first 5 months of 1943, facilities were installed to complete the storage project as recommended. One of the attractive features of the entire proposal as pointed out by Dodge and Wehe in their report was that practically all the essential supplies and equipment required to convert the field to gas storage were available either as normally carried stock or as second-hand equipment procurable in the field where they were to be used.

The project involved the installation of compression equipment to be tied into one of the principal gas lines; the establishment of a field collecting and injection system and a purification unit to reduce the hydrogen sulphide content of the gas to permissible proportions. The field injection and withdrawal lines were manifolded into a Southern California Gas Company trunk line some 3½ miles distant. This line serves the dual purpose of providing injection gas during summer, and transporting withdrawal gas to the distributing lines during periods of peak demand. All pipe used was on hand or readily available prior to the institution of the project. So also were eight 200-hp. compressors and such auxiliary compression as was deemed necessary.

THE main compressors were equipped with cylinders for compression from 150 to 500 lb. but a second stage of compression to 1500 lb. was needed to cope with rising pressures in the formation as the amount of stored gas increased. The gas supply from the trunk line is delivered at approximately 150 lb. and as the normal bottom hole pressure is only some 30 to 100 lb. a large storage could have been contrived with the original cylinders. As a geological survey of the reservoir showed that for each 384,000,000 cu. ft. of gas stored a rise in reservoir pressure of 100 lb. was to be expected, it became obvious that in reaching the full objective of 2 billion cubic feet of storage with a billion backlog, a maximum injection pressure in excess of 1000 lb. would be required. To accomplish this second stage of compression,

Compressors used by Southern California Gas Company to build up the requisite pressures for injection. These were used machines and were all that were available when the storage project was initiated.



thus, it was necessary to equip a number of the engines with high pressure cylinders.

Most of the wells were already provided with the necessary tubing and heads for injection purposes, but a number had to be so manifolded as to make them adaptable to either injection or withdrawal. Supplies, however, were available on the ground for this purpose, as also were the oil and gas separation traps that were an integral part of the overall process.

Injection was actually begun in June, 1943, under an arrangement whereby the Southern California Gas Company pays Defense Plant Corporation specific charges for the use of the reservoir as a storage plant. The gas company owns the compressor plant and injects the gas. Several hundred barrels of oil are still produced in the field, but it was believed highly advisable in the emergency situation to subjugate the small oil yield to the greater urgency of the gas program. The gas for storage is derived mostly from coastal fields such as Ventura, Rincon, Elwood, and Goleta and is brought in through a 26-in. line that is also connected to the San Joaquin Valley. It is interesting in this discussion, incidentally, that in recent years the growing practice of returning gas to formation to be utilized as a lifting medium was responsible to a considerable degree for the shortage of gas during the war period.

In the beginning, the Del Rey field took gas right out of the line, but as pressure in the reservoir built up it was necessary to resort to compression. About 10 wells were used for injection and some 2 billion cubic feet of gas were forced into the formation in the first year of operation. A single line runs from the compressor plant to a header in the field and many of the wells are equipped so that they can either be employed for injection or withdrawal. The wells are also provided with gas traps so that water and oil can be removed.

To date some 5 billion cubic feet have been stored for varying lengths of time and the project has been highly successful from every viewpoint. It was designed to meet and did meet in a very adequate way, a problem in which the national security was involved. In addition it was an adventure in operational practice that will doubtless prove of great value to the industry, for it has demonstrated that with a proper understanding of sub-surface conditions, a closed reservoir in a depleted field can be used satisfactorily and economically for gas storage. This, of course opens up a wide new area of thought for exploitation, and there is no question that the forward-looking oil and gas industries will utilize the experience gained to advance further the conservation measures that are so essential to the efficient conduct of their respective operating processes.

It is unfortunate that diverse and scattered interests make it virtually impossible in peace time to pursue such basically rational programs as that which has been described but unanimous agreement and concentrated action are not easy to arrange in a large field in which ownership is comprised of many small holdings. There is a very decided tendency in the direction of unification in all phases of field operation that can be adapted to it, however, and the beneficial results of this type of action are bound to stimulate additional efforts in sympathetic rather than competitive ownership.

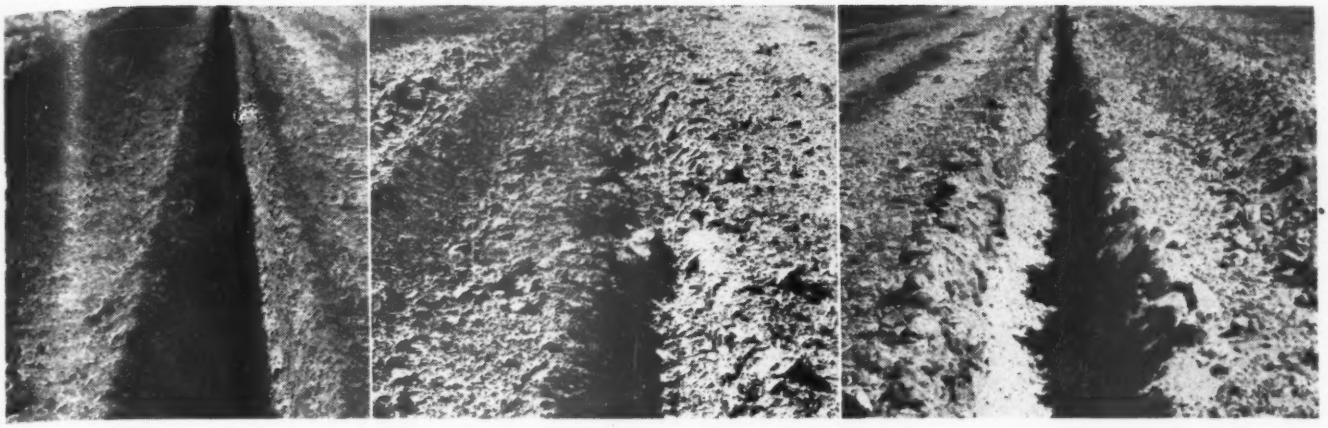
Again referring specifically to the Playa del Rey project, it is to be remarked that the success of this enterprise is attributable in no small degree to the fine cooperation that was manifested between Government and industry. From the inception of the program right up to the present time, the various state and federal agencies, their consultants and representatives, together with the representatives and operators designated by Southern California Gas Company and Union Oil Company of California, have apparently found it easy to plan, construct, and operate the unique storage plant in understanding concert and complete harmony. ★ ★ ★

P 425.219

DEVICE FOR HANDLING HEAVY MUD PUMP SUCTION HOSE

A QUICK, easy way to handle the heavy suction hose to a mud pump has been devised by workmen on a rig in the Carthage field. An A-frame, as shown in the accompanying illustration, is made from 12-ft. lengths of 2½-in. tubing hinged to lugs welded to the pump skids. A suitable chain holds the A-frame at the proper angle over the mud pit.

The winching mechanism has been made from a discarded 4-in. cathead welded to a 10-in. gear that meshes with a 2-in. pinion. A 14-in. wheel from a gate valve gives added leverage, and a stop-pawl holds the winch while under load. Soft-laid line, ¼-in. in diam., extends from the winch over a 4-in. pulley at the top of the A-frame and down to a lug welded 4 ft. back from the suction pipe elbow. This device is especially helpful while rigging up in snaking the heavy suction hose and pipe into position for flanging up. ★ ★ ★



Pipe line trenches. Left—A dirt-finished ditch. Center—In rocky terrain. Right—After rock has been blasted.

PIPE LINE CAPACITY INCREASED BY LOOPING

By **FRANK H. LOVE,** *Managing Editor*

GULF REFINING COMPANY, Houston Pipe Line Division, has underway an extensive looping project that, when completed, will increase the capacity of its system from the West Texas area to the company's Port Arthur refinery by 25,000 bbl. a day. The program includes the laying of 472.25 miles of 8, 10, and 12-in. line and the addition of pumping equipment at each of 12 stations. To November 15, 175 miles of pipe had been laid and this part of the work is expected to be completed by January 15. New pumping equipment will not be completely installed until July 1, however, due to difficulty in obtaining deliveries. As a result, liners are being changed in existing pumps to lower pressure and increase capacity. As soon as the pipe is laid the system can obtain an increase in capacity of 15,000 bbl. a day, and an additional 10,000 bbl. a day can be obtained when the new equipment is placed in operation about July 1.

EXCLUSIVE

● **Existing lines and new loops.** From the Keystone pool in West Texas to Midland Gulf has a 62-mile 8-in. line and this is being paralleled. By so doing the capacity of that section of line will be increased to 42,500 bbl. a day.

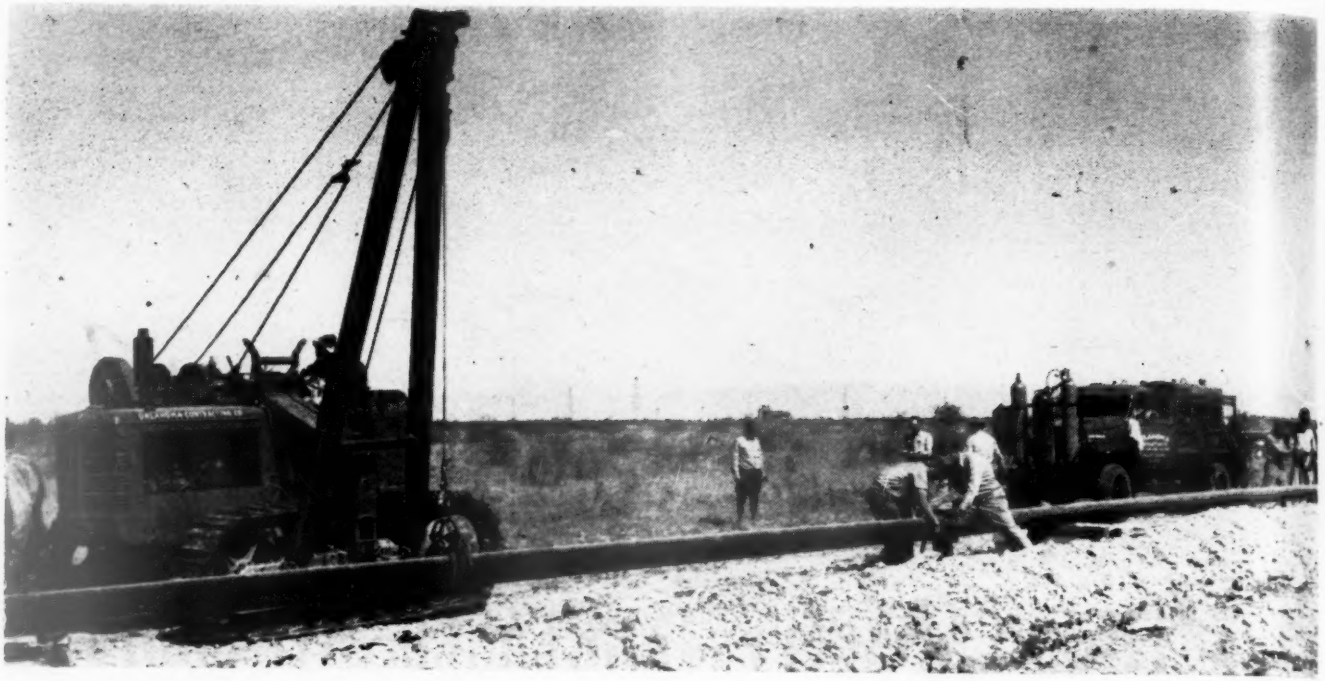
On the discharge side of the Judkins station 8.12 miles of 10-in. pipe is being laid, which will give the company parallel 10-in. lines between Judkins and Midland, a distance of 40.75 miles, and increase the capacity of that section to 45,000 bbl. a day.

Between Midland and Coahoma an existing 10-in. loop is being extended by 38.96 miles. As Gulf already has two 10-in. lines between Midland and Coahoma, the new work will give the company three parallel lines except for 5.25 miles immediately east from Midland.

From Coahoma to Roscoe two 10-in. lines each 42.12 miles in length exist, plus 10 miles of 10-in. on the suction side of the Roscoe station. This 10-mile section is being extended 28.39 miles.

Between Roscoe and Clyde stations there are two 10-in. lines and a 6.58-

Through rocky soil of West Texas the ditcher makes as much of the trench as possible, after which the rock is blasted and removed from the ditch.



Installing a clamp to hold joints in place while tack weld is made.

Specifications call for metal of finishing beads to come flush with pipe surface.

mile 10-in. loop. The loop is being extended by 45.31 miles.

Two 10-in. lines, each 56.56 miles in length, are in operation between Clyde and Ranger, as well as a short 10-in. loop 5.53 miles in length. This short loop is being extended by 42.92 miles of line.

On the discharge side of the Ranger station 24.67 miles of 10-in. is being laid. Gulf already has two 8-in. and one 10-in. line between Ranger and Weatherford, a distance of 44½ miles.

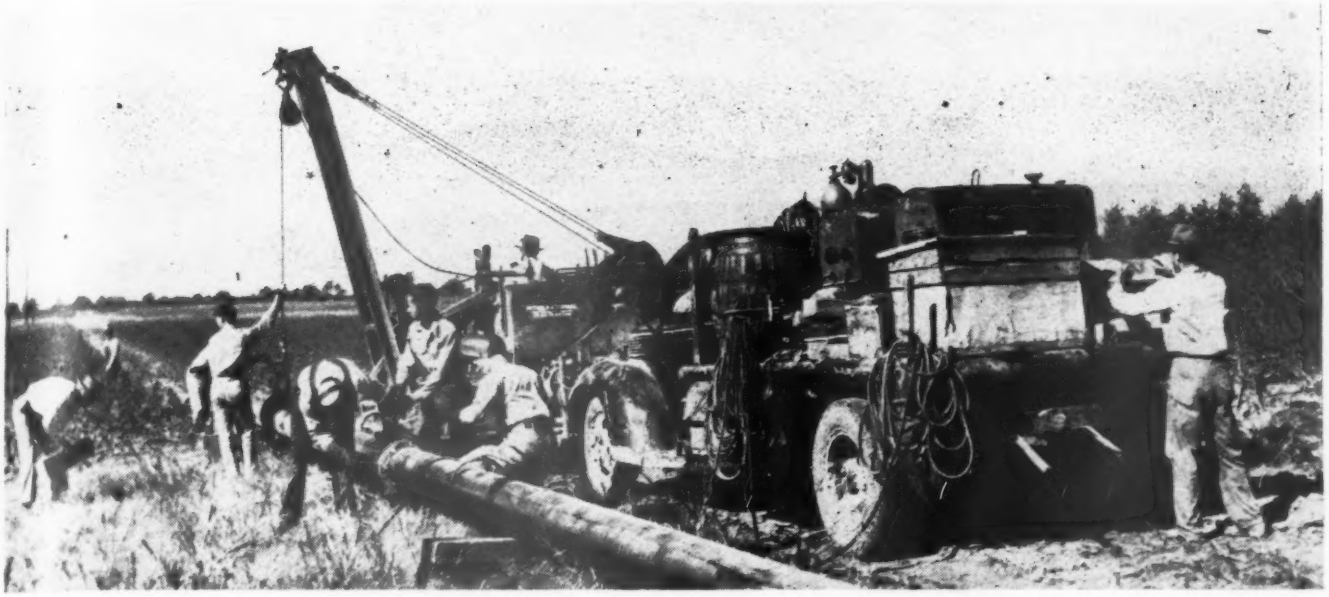
At Weatherford a single 8-in. line branches in a northeast direction, passes near Fort Worth with a short branch line going to Gulf's refinery at that point, on through Garland, Greenville, and to Saltillo where it connects with the company's main trunk system. On the discharge side of the Weatherford station on the line going to the Gulf Coast area, 17.55 miles of 10-in. line is being installed. This will fill out the company's No. 2 line giving it two 10-in. lines between Weatherford and the next station at Grandview. In addition, a 10-in. loop 10.75 miles long is being laid immediately west of Grandview.

Between Grandview and Wortham 16.75 miles of pipe will fill out the No. 2 10-in. line. Also being laid is 18.75 miles of 10-in. pipe to the suction of the Wortham station.

There are two 8-in. and one 10-in. lines between Wortham and Elkhart. One of the 8-in. lines is being filled out by the laying of 19.90 miles of pipe, the No. 2 10-in. line is being filled out by the laying of 12.26 miles of pipe, and in addition an 11.57-mile 10-in. loop is being laid.

Between Elkhart and Lufkin, a distance of 51.52 miles, the No. 2 10-in. line is completed with 31.43 miles of pipe, and 8 miles of 8-in. loop is being laid.

At Lufkin the West Texas system ties in with Gulf's main trunk line from Port Arthur to the north. From Lufkin to



Scene of construction work near Wortham, Texas. Workmen are adding one joint of pipe at a time, which is known as the stove-pipe method.

TABLE 1

From	To	Pipe size and mileage			
		8-in.	10-in.	12-in.	14-in.
		Miles	Miles	Miles	Miles
Keystone	Midland	62.007	..	..	..
Judkins	Midland	..	8.12	..	..
Midland	Coahoma	..	38.96	..	..
Coahoma	Roscoe	..	28.39	..	..
Roscoe	Clyde	..	45.31	..	..
Clyde	Ranger	..	42.92	..	..
Ranger	Weatherford	..	24.67	..	..
Weatherford	Grandview	..	28.30	..	..
Grandview	Wortham	..	35.86	..	..
Wortham	Elkhart	19.90	23.84	..	..
Elkhart	Lufkin	8.00	31.43	..	..
Lufkin	Chester	..	..	14.872	..
Chester	Sour Lake	..	..	29.600	..
Sour Lake	Port Arthur	..	29.44	..	0.635
	Total miles	89.907	337.240	44.472	0.635

Lowering pipe into ditch, using but one side-boom tractor. Slack loops are left up on skids to be lowered in the cool of the morning.

Port Arthur the system consists of a maze of pipe lines varying in diameter from 6 in. to 14 in. Between the Lufkin and Chester stations the 12-in. line is being filled out by the installation of 14.87 miles of pipe. From Chester to Sour Lake the 12-in. line is also being filled out by the laying of 29.6 miles of pipe, and the 10-in. line between Sour Lake and Port Arthur is being completed with 29.44 miles of pipe. In the vicinity of the Port Arthur refinery 0.635 mile of 14-in. line is also being laid.

● **Pumping stations.** As mentioned, an increase in pumping capacity will be obtained when the new loops are completed by means of revamping existing pumping equipment. Maximum capacity will not be possible, however, until new pumps and engines are installed. When this has been accomplished the capacity of the line from Midland east will be 108,000 bbl. a day.

There are 12 pumping stations on the system between Midland and Port Arthur and the old equipment, varying from 3 to 13 units per station, consists of diesel engines driving plunger-type pumps. An idea of the power distribution can be obtained from the following horsepower capacities of the various stations: Midland, 1500 hp.; Coahoma, 1500 hp.; Roscoe, 1500 hp.; Clyde, 1300 hp.; Ranger, 1500 hp.; Weatherford, 1500 hp.; Grandview, 1300 hp.; Wortham, 1300 hp., and Elkhart, 1300 hp. As the West Texas system forms a junction at Lufkin with the company's main line, pumping equipment at that station, as well as at Chester and Sour Lake, is considerably greater than for those stations enumerated.

At each of the 12 stations a 6-cylinder 860-hp. diesel engine is to be installed, which will be connected through speed increasing gears to a centrifugal pump. The prime movers will operate at a speed of 360 r.p.m. and the pumps at 3550 r.p.m.

● **Construction features.** The right-of-way from West Texas to the Gulf Coast

The rocky nature of the West Texas terrain is very much in evidence here. The welder is running a finishing bead.

passes through numerous types of terrain—rocky soil found in abundance in West Texas, loam, sand, and the piney woods of East Texas.

For the most part conventional pipelining methods are being employed. Staking the right-of-way for the stringing crews is a comparatively simple matter due to the fact that the new loops are being laid, of course, along the same route as the lines already in use. After the pipe is strung, the ditching machine is run to make the trench. On the west end of the line, hard rock is immediately below a thin layer of topsoil. Here a ditching machine removes what soil and rock it can, the harder rock then being blasted. Ahead of the welders the bending crews make the necessary sag bends, over bends, and side bends. All bends are made cold.

The general procedure of construction is by the stove-pipe method. Lining up by means of side-boom tractors, the pipe joints are held in place by a clamp while tack welds are made. The pipe is then lowered onto skids to await the finish welders. One tack weld is made and two or more finish beads, specifications requiring that the weld metal be flush with the outside surface of the pipe.

The pipe is Grade B seamless with plain ends and is delivered in 40-ft. random lengths. Weight of the 8-in. pipe is 28.55 lb. per linear ft., the 10-in. pipe weighs 40.48 lb., and the 12-in. 49.56 lb.

After the joints are welded and the pipe lowered onto skids, the next step is lowering into the ditch. Slack loops are left up at specified intervals and crowded into the trench in the cool of the morning to provide for expansion and contraction of the pipe.

On the Sour Lake-Port Arthur section of the line 29.5 miles of 10-in. pipe is being coated with hot enamel and wrapped with asbestos felt. The rest of the line is being laid bare.

The right-of-way of the line is such that it is necessary to cross only two rivers, the Trinity and the Neches. Single lines have been laid at these points. The rivers are narrow but swift. The pipe was welded on shore, weighted with clamps, and pulled into a trench previously prepared. Inasmuch as the older lines were uncovered during this operation, the opportunity was taken to replace them with new pipe.

● **Contractors.** Construction work is being done by three contractors: Associated Contractors and Engineers, Houston, Texas; Oklahoma Contracting Company, Dallas, Texas, and J. R. Horrigan Construction Company, Houston.

★ ★ ★

Frequently a new pipe line crosses old ones and has to be laid beneath them. Here workmen dig a ditch by hand beneath three lines in a West Texas oil field.

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NEW FLUID CATALYTIC CRACKING UNIT DESIGN

By **N. K. ANDERSON** and **M. J. STERBA**

Universal Oil Products Company

As a result of experience gained through design and operation of numerous fluid catalytic cracking units built during the war for the production of aviation gasoline, a new simplified catalytic cracking unit has been designed for smaller refineries*.

The many improvements and simplifications embodied in the new fluid type design result in a marked reduction in investment cost, as well as substantial decreases in operating, maintenance, and utility requirements. Despite these economies, there is no sacrifice in performance; in fact, results show an actual improvement in processing efficiency. All improvements embodied in the new unit have been demonstrated in pilot plants, semi-commercial scale, or commercially operated units.

As an illustration of the flexibility of the fluid process, commercial units have been operated with reactor temperatures ranging from as low as 800°F. to as high as 1000°F. Stocks processed commercially have ranged from gasolines to topped crude fed directly to the catalyst section without preflashing. Various recycling operations and combinations of catalytic and thermal cracking operations have been investigated. The inherent flexibility of the fluid catalytic cracking unit plus the economies of the new design combine to make this unit attractive to the smaller refiner who is faced with the problem of increasing the octane rating of his motor gasoline.

● **Flow diagram.** Briefly the flow shown by Fig. 1 is as follows: The oil feed is charged as a liquid at the base of the reactor riser; hot catalyst from the regenerator enters the riser at the point of oil injection, supplies the process heat requirements and is transported upward by the vaporized oil into the reactor.

Spent catalyst is withdrawn continuously from the upper part of the reactor dense phase to hold the level in the reactor and passes downward through the stripping section into the regenerator. Inert gas, prepared by water scrubbing a small portion of the flue gas, is used for stripping.

Catalyst passes downward through the regenerator countercurrent to the air supplied at the bottom for combustion Additional stripping of the spent catalyst is obtained in the upper section of the regenerator where the bulk of the flue gas from the combustion of coke in the lower sections contacts the incoming catalyst.

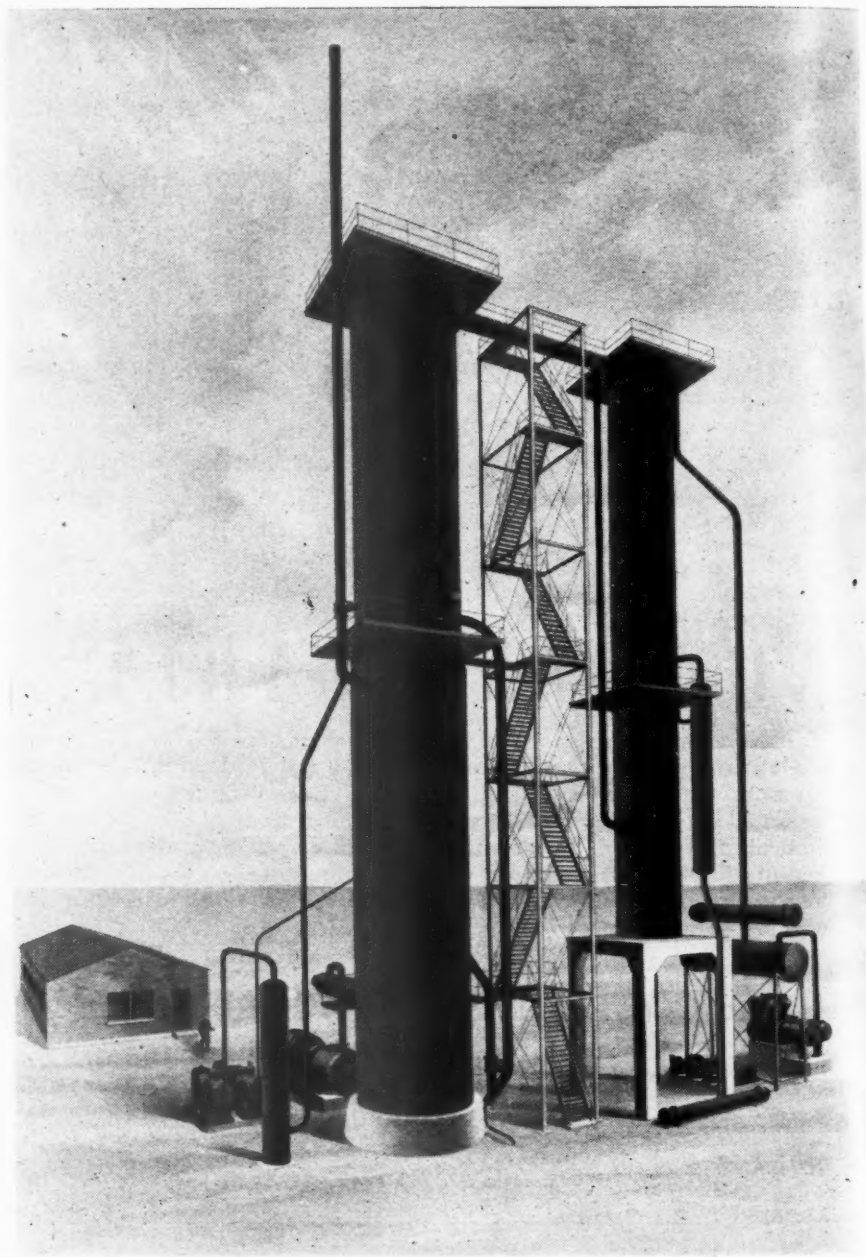
Regenerated catalyst flows from the lower section of the regenerator into the reactor riser at a rate controlled to maintain a constant reactor temperature. The regenerator flue gas is vented to the atmosphere through an internally mounted cyclone separator, which recovers entrained catalyst and returns it to the regenerator dense phase.

The reaction products pass into the fractionator vapor line through an internally mounted cyclone separator, which recovers entrained catalyst and returns it to the reactor dense phase. The vapors enter a fractionating column where column bottoms, a side-cut stream, gasoline, and gas are prepared in the customary manner. Heat is recovered by circulating column bottoms through a steam generator and returning the oil stream to the fractionator at an intermediate point. Adequate facilities for stabilizing the gasoline and preparing polymerization feed have been provided.

● **Discussion.** The major modifications in the new unit compared with the fluid catalyst cracking units of earlier design are:

1. *The reactor and regenerator have been combined into a single vessel,*

New catalytic cracking plant.



*By Universal Oil Products Company, Chicago, Illinois, known as the MS-type.

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which is erected as a self-supported column and is completely shop fabricated for moderate size units. In all sizes, the heavy structure required in the earlier units has been eliminated.

2. *The large regenerator riser has been eliminated, the regenerator standpipe is greatly shortened, and there has been a general elimination and simplification of small piping.*
3. *All equipment for secondary catalyst recovery, such as a precipitator or an oil scrubber on the regenerating side, and a slurry settler or slurry recirculating system on the processing side, has been eliminated.*
4. *The efficiency of both the reactor and regenerator has been improved by the use of additional distribution grids in each section.*
5. *The air supplied for combustion passes through the regenerator countercurrent to the flow of catalyst.*

Savings in investment, maintenance and operating costs here resulted from the changes enumerated in the first three points. Paralleling this simplification process, there has been a redesign of the remaining elements of the plant to make them function with the greatest possible efficiency. The following changes have been made:

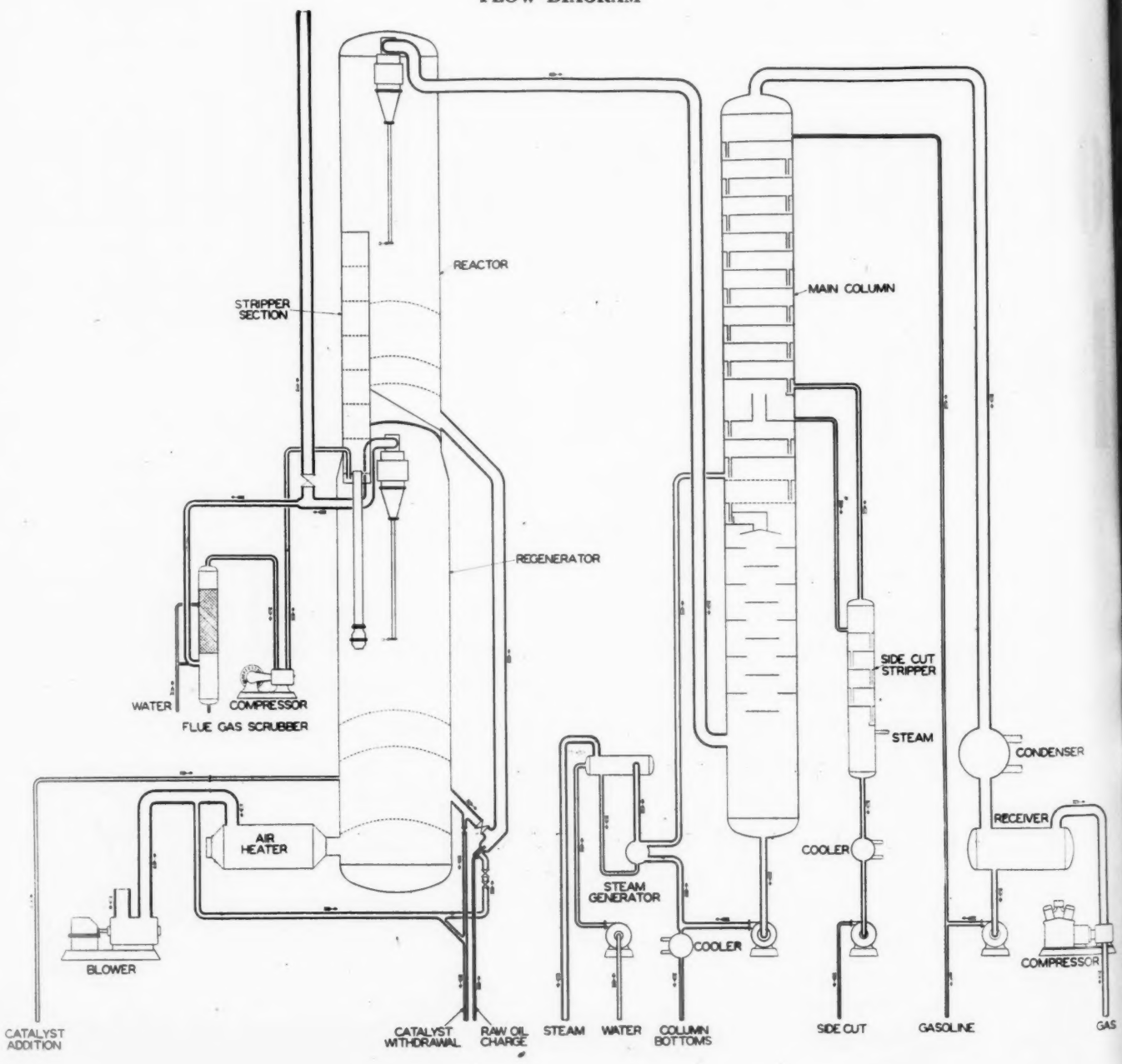
1. *Unlined pipe is used throughout the unit.*
2. *The countercurrent regenerator results in only air passing through the main distribution grid. The distribution is simple and positive.*
3. *The system of catalyst flow control has been modified to reduce erosion on the control valves. Experience in the field indicates that these changes have eliminated this difficulty.*
4. *The design of the cyclone separators used in the new unit is such that maintenance is a minor item.*
5. *A monolithic regenerator lining of refractory cement has replaced the former brick lining.*

TABLE 1.

Typical yields and product qualities obtained by new catalytic cracking unit processing Mid-Continent gas oil in a once-through operation at 65 per cent conversion

Catalyst	Silica-magnesia	Natural	Silica-alumina
Yields, vol. per cent			
Debutanized 400°F. E.P. gasoline	53.0	48.9	45.5
Cycle stock, 400°F.+	35.0	35.0	36.0
Butylenes	5.5	5.8	6.2
Butanes	5.5	7.4	10.9
Propylenes	3.8	4.8	6.6
Propane	1.9	3.4	3.7
C_2 and lighter gas, wt. per cent	1.9	1.7	1.7
Debutanized 400°F. E.P. Gasoline (5-6 lb. R.v.p.)			
Octane no. ASTM (F-2)			
Clear	79.1	80.3	82.1
+3 cc. TEL	85.2	86.5	87.7
Octane no. research (F-1)			
Clear	89.0	90.8	93.0
+3 cc. TEL	95.4	96.5	98.7
Cycle stock, 400°F.+			
Gravity, deg. API	26	26	26
C_2 and lighter gas			
Molecular weight	12	12	14
Heating value, B.t.u. per cu. ft.	740	740	840

FLOW DIAGRAM



Merry Christmas

TABLE 2.

Production summary for once-through catalytic cracking of Mid-Continent gas oil.

Catalyst form	Microspherical Silica-magnesia			Powdered Natural			Microspherical Silica-alumina		
Type catalyst									
Charge, bbl. per calendar day	900	2700	4500	900	2700	4500	900	2700	4500
Conversion, 100-vol. per cent cycle oil	65	65	65	65	65	65	65	65	65
C_3 and lighter, M. cu. ft. calendar day	164	494	822	147	441	735	126	379	631
C_3 and lighter, 10^6 B.t.u. per calendar day	121	363	605	108	375	541	106	319	531
Propylene, bbl. calendar day	36	108	180	43	129	215	61	183	305
Propane, bbl. calendar day	17	51	85	31	92	153	34	101	168
Butylenes, bbl. calendar day	50	150	250	52	156	260	56	168	280
Isobutane, bbl. calendar day	39	117	195	54	161	268	82	246	410
N-butane, bbl. calendar day	10	30	50	13	40	67	16	48	80
Debutanized, 400°F. E.P. gasoline, bbl. calendar day	477	1430	2385	440	1320	2200	409	1230	2045
Cycle oil, bbl. calendar day	315	945	1575	315	945	1575	315	945	1575
Overall yields without polycmerization:									
10-lb. R.v.p., 400°F. E.P. cat. crkd. gasoline, bbl. calendar day	503	1510	2515	463	1390	2315	431	1291	2155
10-lb. R.v.p., 400°F. E.P. cat. crkd. gasoline, vol. per cent	55.9	55.9	55.9	51.5	51.5	51.5	47.9	47.9	47.9
Cat. crkd. gasoline F-2 ON clear	79.8	79.8	79.8	80.9	80.9	80.9	82.4	82.4	82.4
Cat. crkd. gasoline F-2 ON+3 cc. TEL	86.7	86.7	86.7	87.9	87.9	87.9	88.6	88.6	88.6
Excess butanes, bbl. calendar day	63	189	315	84	252	420	117	350	583
Cycle oil, bbl. calendar day	315	945	1575	315	945	1575	315	945	1575
Fuel gas, M. cu. ft. calendar day	264	790	1317	282	845	1410	300	901	1501
Fuel gas, 10^6 B.t.u. per calendar day	368	1103	1840	443	1330	2216	536	1610	2682
Overall yields with polymerization:									
10-lb. R.v.p., 400°F. E.P. cat. crkd. gasoline, bbl. calendar day	503	1510	2515	463	1390	2315	431	1291	2155
10-lb. R.v.p., 400°F. E.P. cat. crkd. gasoline, vol. per cent	55.9	55.9	55.9	51.5	51.5	51.5	47.9	47.9	47.9
10-lb. R.v.p. motor polymer, bbl. calendar day	54	162	270	60	179	299	72	217	362
10-lb. R.v.p. motor polymer, vol. per cent	6.0	6.0	6.0	6.6	6.6	6.6	8.0	8.0	8.0
Total 10-lb. R.v.p. gasoline, bbl. calendar day	557	1672	2785	523	1569	2614	503	1508	2517
Total 10-lb. R.v.p. gasoline, vol. per cent	61.9	61.9	61.9	58.1	58.1	58.1	55.9	55.9	55.9
Excess butanes, bbl. calendar day	19	57	95	38	113	188	66	197	329
Cycle oil, bbl. calendar day	315	945	1575	315	945	1575	315	945	1575
Fuel gas, M. cu. ft. calendar day	224	672	1120	247	742	1237	232	694	1158
Fuel gas, 10^6 B.t.u. per calendar day	276	828	1380	363	1089	1814	377	1130	1884
Cat. crkd. gasoline F-1 (research) ON clear	89.7	89.7	89.7	91.2	91.2	91.2	93.5	93.5	93.5
Cat. crkd. gasoline F-1 ON+3 cc. TEL	96.3	96.3	96.3	97.2	97.2	97.2	99.5	99.5	99.5

TABLE 3.

Summary of operating costs for new catalytic cracking units.

Catalyst form	Microspherical Silica-magnesia			Powdered Natural			Microspherical Silica-alumina		
Type catalyst									
Charge throughput, bbl. calender day	900	2700	4500	900	2700	4500	900	2700	4500
Operating costs per calendar day:									
1. Operating supervision at $350 per month	$11.70	$11.70	$11.70	$11.70	$11.70	$11.70	$11.70	$11.70	$11.70
2. Operating labor at $1.20 per hr. (average)	86.40	115.20	115.20	86.40	115.20	115.20	86.40	115.20	115.20
3. Maintenance labor and materials	66.00	132.00	182.00	73.00	146.00	269.00	66.00	132.00	182.00
4. Utilities	48.70	114.10	164.90	51.70	123.10	176.50	48.70	114.10	164.90
Net steam at 25 cents per M. lb. Circ. water at 2 cents per M. gal. Fuel at 15 cents per MM. B.t.u. Electricity at 1 cent per kw-hr.									
5. Laboratory (additional) labor and chemicals	48.80	48.80	48.80	48.80	48.80	48.80	48.80	48.80	48.80
6. Catalyst	67.50	202.50	337.50	27.00	81.00	135.00	67.50	202.50	337.50
7. Royalty	45.00	135.00	225.00	45.00	135.00	225.00	45.00	135.00	225.00
8. Taxes and insurance	22.00	44.00	61.00	25.00	49.00	90.00	22.00	44.00	61.00
	$396.10	803.30	1146.10	368.60	709.80	1071.20	396.10	803.30	1146.10
Cost per bbl. charge (cents)	44.0	29.8	25.5	41.0	26.3	23.8	44.0	29.8	25.5

TABLE 4.

Summary of operating costs for UOP liquid feed catalytic polymerization units.

(To complement catalytic cracking operating costs in Table 3)

	1	2	3	4	5	6	7	8	9
10-lb. R.v.p. polymer produced, bbl. calendar day	54	162	270	60	179	299	72	217	362
Operating costs per calendar day:									
1. Operating labor at $1.20 per hr. (average)	$28.80	$28.80	$28.80	$28.80	$28.80	$28.80	$28.80	$28.80	$28.80
2. Maintenance labor and materials	8.00	10.30	15.00	8.00	10.30	15.00	8.00	10.30	15.00
3. Utilities	15.60	40.20	65.40	17.00	44.00	72.10	19.80	52.70	86.70
Steam at 25 cents per M. lb. Circ. water at 2 cents per M. gal. Fuel at 15 cents per MM. B.t.u. Electricity at 1 cent per kw-hr.									
4. Laboratory (additional)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
5. Catalyst	6.70	20.20	33.60	7.40	22.30	37.20	9.00	27.00	45.10
6. Royalty	10.10	30.20	50.40	11.10	33.40	55.80	13.45	40.50	67.60
7. Chemicals	3.80	11.40	18.90	4.20	12.55	21.00	5.00	15.20	25.40
8. Taxes and insurance	6.20	8.00	11.70	6.20	8.00	11.70	6.20	8.00	11.70
	$87.20	$157.10	$231.80	$90.70	$167.35	$249.60	$98.25	$190.50	$288.30
Cost per gal. 10-lb. R.v.p. polymer produced (cents)	3.85	2.31	2.04	3.60	2.22	1.99	3.25	2.09	1.90

● **Improvements in efficiency.** It has long been felt that more effective use could be made of the catalyst in the reactor both in regard to conversion and product distribution. It has been found that the installation of additional grids achieves both purposes. First, it permits running at higher space velocities for a given conversion; second, it improves the product distribution by giving more gasoline and less gas and coke at a given conversion. Both effects are quite appreciable. The grids function to prevent circulation of catalyst and reaction products (principally gasoline) from the top of the reactor dense phase toward the bottom. The circulated reaction products acted to decrease the effective oil partial pressure and hence, decreased conversion; at the same time, recirculated gasoline was cracked further to gas and coke, resulting in a loss of yield. The installation of additional grids has improved the processing efficiency of the reactor.

The stripper has been completely redesigned and several installations indicate considerable improvement resulting from the changes. It has been so arranged in the reactor that flow of spent catalyst from the reactor dense phase into the stripper can occur only at the top of the reactor dense phase while the level is allowed to vary. This gives a true top drawoff of spent catalyst from the reactor and obviates bypassing of regenerated catalyst and unconverted raw oil into the stripper. This same feature enhances the effect of the additional grids in the reactor.

To improve the primary function of the stripper, i.e., to remove oil vapor from the spent catalyst going to the regenerator, the geometric proportions have been changed to give a stripper with a high length to diameter ratio; in addition, the stripper has been staged by adding grids. Both mechanical changes result in marked improvement in stripping of spent catalyst by reducing "end-over-end" mixing.

With the countercurrent flow of catalyst and air through the staged regenerator it has become possible to improve its efficiency. The countercurrent flow makes feasible complete oxygen utilization with the additional feature of another period of hydrocarbon distillation and stripping of the spent catalyst in the upper section of the regenerator where the bulk of the flue gas from the combustion of coke in the lower sections comes in contact with the incoming catalyst. These points, together with the redesign of the reactor, which improves the product distribution, permit a substantial reduction in regeneration requirements, both in vessel size and in air quantity.

The more favorable carbon-oxygen relationship in this staged regenerator results in an increased carbon burning rate despite the considerably lower average temperature of the dense phase. In addition, the regenerator is designed to run under pressure, which further increases the carbon burning rate.

● **Catalyst activity.** This increase in burning rate, at a given temperature, effected by staging the regenerator with counter-current operation at a higher pressure, permits an appreciable reduction in the volume of catalyst required in the combustion zone. This point is directly related to the question of catalyst consumption in the cracking process. Hence, at this time the general case of catalyst deactivation and mechanical losses will be considered.

Catalyst deactivation is primarily a function of high temperature plus steam, when no substantial contamination of the catalyst is occurring. The steam can be either that absorbed and occluded by the catalyst in the present strippers or that formed in the regenerator by the combustion of hydrogen-bearing catalyst deposits; the high temperature zone is in all cases the regenerator.

The source of steam in the first instance can be eliminated by going to inert gas stripping. This has been done, with a simultaneous redesign of the stripper to permit low stripping gas rates in order to avoid overloading the gas concentration equipment.

In the case of steam from combusion the effect can only be minimized. This was accomplished first by improving the stripping of the spent catalyst, which reduces preferentially the amount of hydrogen-rich material entering the regenerator. Second, it was done by taking advantage of the countercurrent flow of catalyst and air to stage the regenerator. There are three stages: At the top, there is a low temperature section with little or no combustion, acting as an additional stripping and hydrocarbon distillation zone; next, a zone of moderate temperature wherein the remaining hydrogen-rich material is burned with the least ill effect, and finally, a small high temperature zone where the combustion of low hydrogen coke takes place.

The above-named features of the new unit substantially decrease the rate of catalyst deactivation. Their effect is augmented by the lower average regenerator temperature and the decrease in volume of catalyst held in that vessel resulting from the higher carbon burning rate realized by the installation of grids and the higher operating pressure.

After evaluation of the above-indicated reductions in the rate of loss of catalyst activity, the emphasis on the question of catalyst consumption becomes one of reducing mechanical losses. In view of this, the development of the M-S type catalyst assumes particular importance. This type catalyst is made in the form of microspheres, extremely resistant to attrition, small enough to be fluidized easily, and large enough to make recovery by a cyclone separator very simple. Furthermore, the abrasion of metal parts is considerably less by the new catalyst when compared to ground powder. Performance tests have verified the desirable properties of the microspherical form and all evidence points to a well balanced catalyst that will minimize the rate of replacement.

Industry can handle conversion difficulties

Frank Phillips, head of the Phillips Petroleum Company, believes that the oil industry will be able to cushion the reconversion shock and retain its employes. In an interview Phillips named as the only possible stumbling blocks "interruptions of operations, strikes and other major differences between labor and management."

"Any reductions in needs for workers created by the shift from war to peacetime production probably can be compensated by the return to shorter working schedules," he continued.

Phillips believes reconversion will not be hard for plants devoted during the war to turning out high octane gasoline for airplanes.

"Some of the high octane fuel plants in this country," he said, "will continue in operation with suitable revisions to fit them into the motor fuel economy. A few will probably continue to manufacture high octane aviation fuel.

"It is doubtful whether many will be converted to production of specialized synthetic materials since their capacities are disproportionately large. A more likely development is that synthetic production will help support their continued operation on motor and aviation fuels. The synthetic materials thus attainable run the entire gamut of organic chemicals."

A trend toward postwar construction of marketing facilities for the industry was foreseen by Phillips. In the immediate postwar years he believes greater emphasis will be placed on marketing and distribution facilities.

● **Catalysts.** The most simple design of the new unit is based on the use of the microspherical synthetic catalyst (MS catalyst). A catalyst in the powdered form, either synthetic or natural, can be used with certain additions to the basic plant design. Two synthetic MS type catalysts, silica-alumina and silica-magnesia, are available. Silica-alumina catalyst would be used if maximum octane rating is the primary consideration. The gasoline yield with silica-magnesia catalyst is substantially higher but the octane rating is lower. Because of the lower cost per pound of the natural catalyst its use should also be considered. This catalyst gives a gasoline yield and octane rating intermediate to the values obtained with the synthetic catalysts but with a higher coke production and catalyst replacement rate. Economic considerations of market requirements and operating costs will govern the choice of catalyst.

● **Tables of yield and cost.** The accompanying tables have been prepared in order to give a comprehensive picture of the yields, productions, and operating costs of the new catalytic cracking unit.

Typical yields and product qualities obtained in a once-through operation on Mid-Continent gas oil with the 3 catalysts at a constant conversion of 65 per cent and a constant reactor temperature are summarized in Table 1.

To illustrate the application of the new catalytic cracking unit, there is shown a summary of the production and operating costs for 3 sizes of operations with each of the 3 catalysts. This study is based on units having gas oil charge capacities of 1000, 3000, and 5000 bbl. per stream day with an on-stream efficiency of 90 per cent.

The production summary with and without subsequent polymerization of the C_3-C_4 olefins is presented in Table 2. A summary of estimated operating costs for the catalytic cracking units is given in Table 3. Operating costs for the complementing UOP polymerization units are presented in Table 4.

Operating costs for the catalytic cracking units are based on receiving a gas oil feed, and cover the entire operation of the unit through absorption, debutanization of the catalytically cracked gasoline, and preparation of a liquid feed for polymerization. The various items of cost together with the corresponding rates used in the estimate are listed separately in Tables 3 and 4.

The catalytically cracked gasoline can be finished in most cases with no treatment other than a caustic wash and the addition of inhibitor.

● **Summary.** In closing, it should be pointed out that the greatest single feature of the fluid type catalytic cracking unit is its flexibility. Commercial fluid units have been operated with reactor temperatures ranging from as low as 800°F to as high as 1000°F. Stocks processed commercially have ranged from gasolines to topped crude fed directly to the catalyst section without preflashing. Various recycling operations and combinations of catalytic and thermal cracking operations have been thoroughly investigated.

The many improvements and simplifications found in the MS-type design have reduced investment and operating costs until they compare favorably with the costs of a thermal cracking unit of the same capacity. This has been accomplished while retaining all the inherent advantages of the original fluid type operation and improving its processing efficiency.

The economies and improved performance of the new design with all of the flexibility of the fluid cracking process make this unit entirely feasible for the smaller refiner who is faced with the need of raising the octane rating of his motor gasoline. ★ ★ ★

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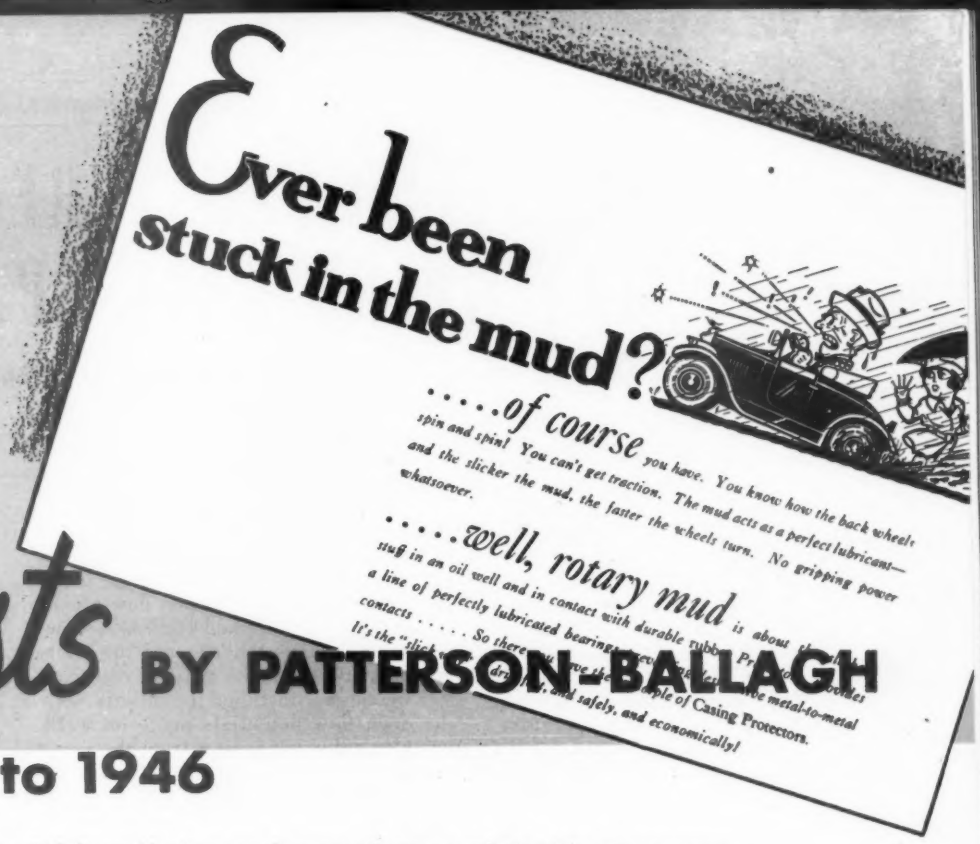
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OIL FIELD SPECIALTIES

OIL YIELD PER ACRE-FOOT MAY GUIDE WELL SPACING

By **K. MARSHALL FAGIN,** *Field Editor*

EXCLUSIVE

A GROWING number of those engaged in the development of new oil fields and new producing formations in old oil fields are becoming aware of the importance of carefully analyzing and recording all the information that can be obtained from the first wells drilled in a new reservoir for the purpose of comparison with the records of oil recoveries from similar formations in older fields. In this way the operators that maintain an adequate set of recovery records are making a scientific effort to guide present development programs by the results being obtained from past programs.

An adequate set of recovery records for an operator may be limited to data on the fields or geographic area in which he is interested, but he, or someone in his organization, perhaps an exploitation engineer will maintain as complete a set of recovery and development records on those fields as time and the availability of information permit. The arrangement of the facts and estimates may vary considerably to suit the convenience of the operator, but the most useful portion of the records are the field summary sheets, field summary cards, or a large table with sufficient columns for recapitulating all the important facts relating to oil production for each field in the area. These records are the ones that supply the most reliable foundation for comparing old developed fields with the new undeveloped fields.

The reliability of the figures kept on these field sheets depends wholly on the searching thoroughness the particular operator exercises in compiling the facts and the care he uses in making his calculations. The importance of knowing the average recovery of crude oil per acre foot from older fields in an area is usually sufficient to stimulate exercising considerable care in the preparation of the basic data, but two persons working independently will seldom arrive at the same figure for a given field, even though most of the basic information used by them is the same. Their answers, however, will usually be comparable, and will serve as a guide for forecasting intelligently the well spacing programs in similar new fields.

● **Reasons for keeping systematic records.** There are many reasons for the operators to delve into the producing records and study the performance of oil reservoirs and set up systematic records of their findings and their opinions based on these findings. One of the chief reasons is the fact that more wells are now being completed through small chokes than ever before. Although this practice contributes to overall production efficiency of the well, and is in the interest of conservation, the open flow potential of the well is masked (unless a drawdown potential is taken), and the operator is unable to make a direct comparison of these controlled potentials with the open flow potentials made on wells in older fields producing from the same formation.

A direct comparison might erroneously indicate that the wells in the new field are considerably better than the wells in the older field, due to simple multiplication by 8 of the production during a 3-hour test to obtain the "initial daily production," when, as a matter of fact, the well would not have been capable of producing nearly so much as this multiplication might indicate. Conversely, the test on the new well might have been taken on such a small choke that the well could have produced considerably more under open flow than multiplication of the potential test indicated.

● **Proration changes production curves.** A second reason for the trend toward keeping better records and spending more time in the study of well and field performance is the fact that most of the new fields are being produced at controlled rates under various systems of proration. This practice also tends to contribute to producing efficiency and increase the ultimate recovery of crude oil production, but it prevents operators from comparing the artificial production decline curve of the newer field with the natural production decline curve of older fields that were operated at or near maximum open flow production rates.

A study of the production curves of the 10 to 15 year old fields in the Mid-Continent and Gulf Coast areas will reveal that many of them produced much more oil during the war years of 1942 to 1944 than they ever produced before. This ability to produce more was anticipated by the operators in many of the greatly restricted fields, but, in many other fields, the ability to produce more oil came as a distinct surprise to many of the operators. On the other hand, many operators were surprised and disappointed to realize that their wells in some "prorated" fields were not capable of making even slight increases in allowable production.

● **Wider spacing increases "flush" period.** Another reason for operators to keep better and more complete records of production and reservoir performance is that well spacing in newer fields is wider than in older fields. In general, this trend toward wider spacing has been mandatory by the recent wartime necessity of conserving material and manpower, but most operators had recognized long ago that many unnecessary wells were drilled in many of the oil fields of the nation, and that oil might be produced from many fields at considerably less expense and with greater efficiency in many cases by wider well spacing. This difference in spacing practice, however, increases the "flush" production period of the new fields compared to the "gusher" production period of the older fields producing from similar formations, and thus increases the importance to the operators of setting up and maintaining more complete crude oil production and reservoir performance records.

The problem of compiling these records in a useful form for various comparative purposes requires that the maximum amount of information about each reservoir as a whole be gleaned from reliable sources in condensed form and be recorded as regularly as possible upon the field summary sheets with the least amount of time and effort. The useful value of these records depends largely on the judgment that the particular operator expends upon the compilation of the information as well as upon the purposes for which the information is used, inasmuch as too little time may be spent in the compilation of facts and too much reliance may be placed upon insufficient evidence. Conversely, but rarely, more time may be spent on the work of compiling the facts than the use of the results and conclusions by an operator will justify. Few, if any, operators have compiled more data about oil producing reservoirs, however, than they can use to good advantage as time passes, and most operators find that it pays to install some kind of a system to assemble and digest many of the relatively insignificant current facts and produce the significant facts for each field as a whole that are needed for intelligent comparisons of one oil producing reservoir with another.

● **Field-wide facts serve many purposes.** Although the main purpose of developing these significant field-wide facts may be to enable the operator to forecast the probable future recovery from

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FIG. 1. Field production and performance record.

Name of State: _____ Area: _____ County: _____ Field and Reservoir: _____

Discovery Well: _____ Location: _____ Nearest Field: _____ Means of Discovery: _____

Type of Structure: _____ Elevation: _____ Top of Pay: _____ Total Depth: _____ Pay Thickness: Total: _____ Net: _____

Nature of Pay: _____ Porosity: _____ Per Cent Porosity: _____ Permeability: _____ Connate Water: _____

Initial Production: _____ bbl. Oil, _____ mcf. Gas, _____ bbl. Water. Method Produced: _____ Date: _____ Spacing: _____

Source of Discovery Data: _____ Gravity of Oil: _____ Sulphur: _____ Shrinkage: _____ Initial Gas-Oil Ratio: _____

Gravity of Gas: _____ Gal. per mcf.: _____ Initial Reservoir Pressure: _____ Datum: _____ Est. Water Level: _____

Date	Production last year, bbl.	Cumulative production, bbl.	Est. prod., acres	Av. net prod., thick.	Total productive, acre-feet	Cum. per prod. acre-ft.	Estimated proved, acres	Av. net proved, thick.	Est. total proved acre-feet	Est. ult. per acre-ft.	Est. ultimate production			Est. total proved reserve, M. bbl.	No. of prod. oil wells	Daily av. prod.			Average acres per well	Average ult. per well	Average res. press., lb.	Remarks
											Bbl. per prod. acre	Total M. bbl. from				Oil, bbl.	Water, bbl.	Gas, M. cu. ft.				
												prod., acres	proved, acres									

NOTE: The reverse side of this ledger sheet may have a large coordinate graph on which to plot the annual production, bottomhole preasures, gas-oil ratios, water production, cumulative oil production, etc., as time and availability of information permit, or it may co tain a smaller graph and leave sufficient room on which to paste a small scale map of the field. The advantages that may be gained by plotting the information usually outweigh the extra time and effort required to keep up this condensed history in graphic form.

a new reservoir and the most effective and profitable well spacing program by comparison with the probable ultimate recovery per acre foot in older producing reservoirs with similar characteristics, the operator may use the facts in many other ways, such as: 1. To determine whether or not he is depleting the acre feet of producing formation under his leases as rapidly as the average acre foot in the field is being depleted. 2. To guide the preparation of estimates of recoverable oil reserves under his leases for tax purposes or appraisal purposes. 3. To provide himself with a condensed history of the development and production progress of the field that will give clear and ample warning of impending operating difficulties that require budgeting such as the need for installing pumps, the need for preparing for water encroachment, the need for remedial work on the wells as well as the feasibility of pressure maintenance, repressuring, or waterflooding.

Those operators who wish to set up a comprehensive system for keeping up with the significant facts pertaining to the fields in the vicinity of their operations will find that it pays to prepare a supply of field summary sheets to fit into a loose leaf ledger, or to prepare a field summary card and to set up a card file on the fields. A large loose leaf ledger system has been found very satisfactory by a number of operators, because it provides space for more of the significant facts to be entered for a greater number of years, and the back of the ledger page can be used for a graphic history.

Auxiliary facts and those that may be available only by monthly or quarterly periods will have to be accumulated on separate ledger sheets and kept in separate field files.

Most operators who set up these field summary ledgers find that it pays to file the individual field (or individual reservoir) sheets alphabetically by field name within each county or parish rather than alphabetically by field name within each district or state. In this manner, the ledger may contain a sheet for all the fields within a district or an area of a state with the fields arranged alphabetically under each county, and each county arranged alphabetically within the district. Then, as new fields are found, a ledger sheet may be inserted to take care of the annual information as it becomes available.

● **Much information is available.** Some of the many sources of the information for installing this system may be enumerated as follows: The production statistics section of the AIME yearbooks, The National Oil Scouts' and Landmen's Association Yearbooks, reports of government regulatory bodies, reports of field engineering committees, reports of statistical services, reports of trade journals and government bureaus, and reports of company field geologists and engineers. The multitude of possible sources and the voluminous nature of many reports must be taken into account when a system is installed. Provision should be made to gather the most

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satisfactory figures available for entry on the field summary ledger sheets.

It is also helpful to keep an auxiliary file of small scale maps of each field on which the proved acreage can be outlined. Then, as extensions are proved, these additional areas can be outlined, measured, and recorded at the end of each year. The purchase of new maps on many old fields may be cheaper than attempting to keep up with large extensions of the fields on the older maps.

Perhaps as much as one-quarter of the field summary sheet may be utilized to provide space for the more or less fixed data on a field such as: name of field and reservoir, name of county or parish, name of district or area, name of state, name of discovery well, location of discovery well, direction from nearest producing field, means of discovery, type of subsurface structure, elevation, top of producing formation (depth in ft.), total depth of discovery well, thickness of oil and gas zone (overall in discovery well), estimated net thickness of oil producing formation in discovery well, nature of saturated portion of producing zone (sand or lime), type of porosity and estimated average porosity, average permeability, connate water, initial production of discovery well (gas, oil, and water) method produced, date, prospective or actual spacing pattern (acres per well), references to sources of data used as well as to other reports and articles available, gravity of oil and gas produced, per cent of sulphur, shrinkage, initial gas-oil ratio, liquid content of gas, the initial reservoir pressure and datum plane, and the estimated reservoir water level.

● **Field sheets should be well planned.** One of the main problems in setting up one of these field recovery and performance ledgers is to select column headings that will provide a place to record all the significant facts without too much crowding of the page and with the least amount of effort. This is an important point, and requires considerable judgment, especially when figures on a large number of fields and reservoirs are to be handled annually, and when one type of field summary sheet is to be adopted for universal use by the operator. It is not surprising, therefore, to find that few operators keep these records on similar forms. Each one has usually installed a system for keeping up with a limited number of fields, and once begun, considerable expense is attached to most changes that may be desired in order to handle a greater number of fields.

Fig. 1 illustrates a field summary ledger sheet that may be set up for universal use by a company operating in many districts.

● **Space must be provided for many facts.** The significant field-wide (or reservoir-wide) facts that may be recorded annually are as follows. It is possible that many of these may be eliminated to conserve space and effort, especially figures that may be readily obtained from others on the form by simply adding, subtracting, dividing or multiplying, but figures believed essential are indicated by heavy type:

DATE (1-1-44, 1-1-45, etc.); PRODUCTION LAST YEAR (bbl.); CUMULATIVE PRODUCTION (bbl.); ESTIMATED PRODUCTIVE ACRES (developed producing acreage); ESTIMATED AVERAGE NET PRODUCTIVE THICKNESS (average total thickness of the oil producing zone less shale and other portions in the saturated zone deemed too impermeable to produce); ESTIMATED TOTAL PRODUCTIVE ACRE FEET (productive acres times net thickness); estimated average recovery per productive acre (cumulative divided by productive acres); estimated average cumulative recovery per productive acre foot (recovery per productive acre divided by net productive thickness, or cumulative divided by total productive acre feet); ESTIMATED PROVED ACRES (productive acres plus acres estimated proved for drilling).

ESTIMATED AVERAGE PROVED THICKNESS (this may be more or less than the net thickness, inasmuch as part of the net producing sand may not be developed by drilled wells, and the best or poorest part of the field may be left to drill. The edge wells are usually the last ones drilled. Therefore, the average proved sand thickness for the field will usually be less than the average net productive thickness of the sand in the first few wells); ESTIMATED TOTAL PROVED ACRE FEET (this is the proved acres times the average proved thickness, and should be more than the total productive acre feet until the field is completely developed).

● **Some headings may be eliminated.** The field summary sheet column headings may be simplified by eliminating either the productive or proved acre, thickness, and total acre feet columns, but it should be borne in mind that oil is not produced from proved acre feet remote from the wells producing from the reservoir sand body until the initial pressure in these remote sections is lowered enough to cause the oil to move to the relatively distant wells, except when a water drive (natural or artificial) aids in this movement.

There are many valid practical and engineering reasons for providing a place on this sheet for both sets of acres and acre feet. Unless this is done copious notes may be needed to explain large reductions in estimated proved acreage, or large additions to estimated productive acreage as time and economic conditions require that estimates be altered.

Productive acreage should grow with every new extension well drilled in a reservoir, and, after a reservoir has been completely developed (the point at which the proved acreage equals the productive acreage), this column might be relabeled by a note to record the shrinking size of a reservoir as producing wells and acres are abandoned. Proved acreage on the other hand should remain more or less constant from the time the true areal extent of an oil reservoir is recognized by the operators from a study of geological maps of the oil-producing portion of a structure.

Other column headings for the field summary ledger sheets may be as follows (essential headings are in heavy type): ESTIMATED ULTIMATE PRODUCTION PER ACRE FOOT (strictly an estimate that should be based on a study of the porosity, saturation, permeability, and characteristics of the sand; the nature of the energy moving the oil into the wells (that is, gas drive, water drive, or gravity); and comparisons of the reservoir with other, older reservoirs); estimated ultimate production per productive acre (estimated ultimate production per acre foot times the average net productive thickness); estimated ultimate production per proved acre (estimated ultimate production per acre foot times the average net proved thickness).

Estimated total ultimate production from productive acres (estimated ultimate production per acre foot times total productive acre feet); ESTIMATED TOTAL ULTIMATE PRODUCTION from proved acres (estimated ultimate per acre foot times total proved acre feet); estimated total future production from productive acres (estimated total production from productive acres less cumulative production); ESTIMATED TOTAL PROVED RESERVE (estimated total ultimate production from proved acres less cumulative production); NUMBER OF PRODUCING OIL WELLS; TOTAL DAILY AVERAGE OIL PRODUCTION (near date of each year's estimate); TOTAL DAILY AVERAGE GAS PRODUCTION (based on average gas-oil ratio, if not otherwise available); TOTAL DAILY AVERAGE WATER PRODUCTION; AVERAGE WELL SPACING (estimated productive acres divided by number of wells); ESTIMATED AVERAGE ULTIMATE PRODUCTION PER WELL (estimated ultimate production per acre foot times estimated average net productive thickness times average well spacing (acres per well), or estimated total production from productive acres divided by the number of wells); AVERAGE RESERVOIR PRESSURE (as of, or near, the date of the entries and estimates); and REMARKS (for dated notes concerning major changes in the methods of operation of the wells in the field, such as: removal of proration controls, introduction of pumping or gas-lift on a wide scale, introduction of repressuring, pressure maintenance, or waterflooding, etc.)

Operators who have not installed a regular system for keeping up with the oil recovery and reservoir performance of fields in the areas in which they are interested will probably be surprised to find how much can be gained by a little time and effort regularly expended in this direction. A study of records such as outlined herein will serve not only to guide an operator in spacing his wells on a profitable pattern, but will also provide him with a keener appreciation of the ultimate value of his wells as oil producers. More mistakes are probably made because of a lack of information than because of a lack of judgment.

★ ★ ★

DEEP DRILLING REVIVES RANGELY FIELD, COLORADO

By **EDMUND F. ESTERGREN,** Algord Oil Corporation

EXCLUSIVE

THE Rangely field is situated in Rio Blanco County, northwestern Colorado. It is 105 miles from the nearest railroad at Craig, Colorado, and 215 miles from Salt Lake City, Utah. Most of the oil field personnel reside at Vernal, Utah, which is 50 miles west, or at the various company camps situated in the field.

Rangely is approximately 60 miles south of the Hiawatha-Canyon Creek fields on the Wyoming-Colorado line, and about 50 miles west of the Wilson Creek field, which, next to Rangely, is one of the best fields in the area.

The Rangely anticline, in its relationship to the regional geology, is situated on the northeastern rim of the Uinta Basin. The Uinta Basin area covers 13,600 square miles in west-central Colorado and east-central Utah, being a major structural basin lying between major uplifts and abutting against the Wasatch mountains on the west. It is believed that 20,000 ft. of strata are present in the deeper parts of the area, ranging in age from Cambrian to Miocene.

● **History of production.** The first oil was discovered in the Rangely field in a shallow well drilled on the east nose of the anticline in 1902. This well produced only 2 to 7 bbl. a day from the Mancos shale at depths of 800 to 1700 ft., and it was soon abandoned. The early history of the field was described by H. S. Gale in 1908 and 1910.

Gale states that 12 wells were drilled in the field between the years 1902 and 1907. After this period of early exploration, drilling lagged until 1919, when the Emerald Oil Company brought in a well making 130 bbl. a day in the Mancos shale from a depth of 521 ft. From 1919 until 1943 many shallow wells were drilled. Most of these wells stopped in the Mancos shale and had an initial production of 5 to 100 bbl. a day.

● **Weber Oil Sand Discovered in 1933.** The present oil boom and extensive drilling campaign was occasioned by a well drilled by The California Company. This well was drilled between 1931 and 1933, and is The California Company's No. 1 Raven in the NW¼ of SE¼ of Sec. 30, T.2N., R.102W. The total depth of the well is 7173 ft. and the well produced oil from beds in the Weber sandstone of Pennsylvania age at depths from 5704 to 6320 ft. This well penetrated all Mesozoic beds below the Mancos shale and extended approximately 1500 ft. into the Pennsylvania series. It had produced about 8000 bbl. of oil and was then shut in due to lack of pipe line facilities until September, 1943, at which time the well was reopened and produced at the rate of 225 bbl. a day. To November 30, 1945, 29 wells and no dry holes had been completed in the Weber horizon. Thirty wells are now drilling, and 9 locations are staked.

● **Geology.** The surface expression of the Rangely anticline is typical of Rocky Mountain folds in that the crest is marked by a surface depression and topographic basin. The Mancos shale and the overlying Mesaverde formation, both of Cretaceous age, are the only rocks exposed on the surface in the Rangely field.

The surface geology was mapped by plane table surveys by the U. S. Geological Survey and is shown on their latest map on the area known as "Oil and Gas Investigations, Preliminary Map No. 41." As mapped on the surface, the crest of the Rangely anticline trends west on the east end and northwest on the west end of the anticline. It is 20 miles long and 8 miles wide. The lowest closed contour takes in an area of approximately 100 square miles and indicates a structural closure of more than 2,00 ft. The dips on the beds on the southwest flank of the anticline are steeper than those on the northeast, ranging from 13 deg. to 21 deg., whereas those on the northeast flank average 6 deg. Several small normal faults trending northeast have been found on the structure, and one trending northwest has been discovered.

Most of these faults have a displacement of less than 100 ft., with the exception of one fault that has a 300-ft. displacement. On all except two faults the downthrow is on the southeast. Considering the amount of closure present and the small amount of displacement on the faults, it is not likely that these faults will materially affect accumulation and subsequent production.

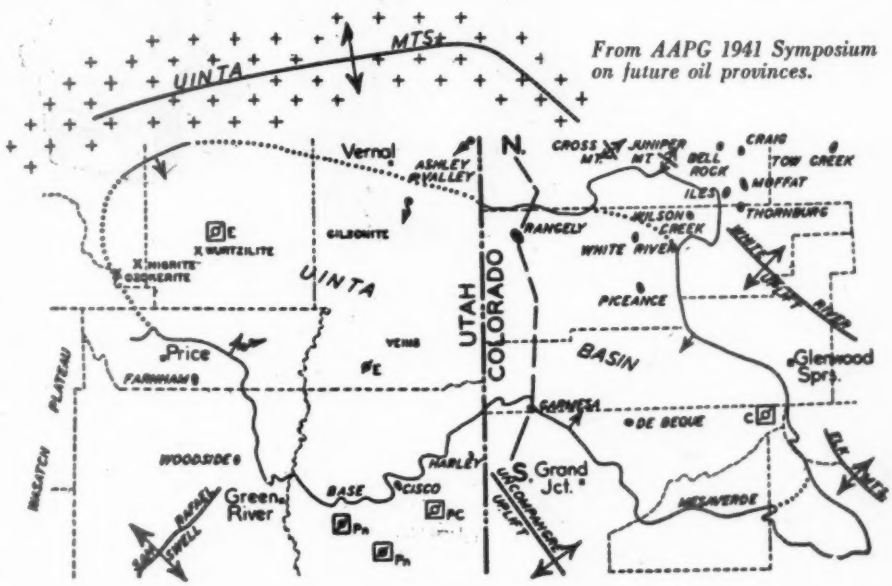
● **Shallow oil found in calcite veins.** One of the most interesting features of the Rangely anticline is the association of calcite veins with the occurrence of oil in the shallow wells producing from the Mancos shale. These veins occupy joints in the shale and are most numerous near the crest of the anticline where the strain and stress was most predominant during folding and which caused the fractured condition. These calcite veins trend northeastward parallel to the trend of most of the faults.

The shallow oil occurs in porous parts of these veins or in fractures in the shale closely adjoining the veins. The apparent dip of these veins is vertical.

The gravity of the oil produced in the shallow wells from the Mancos shale is 42 deg. and the sulphur content is less than 0.1 per cent.

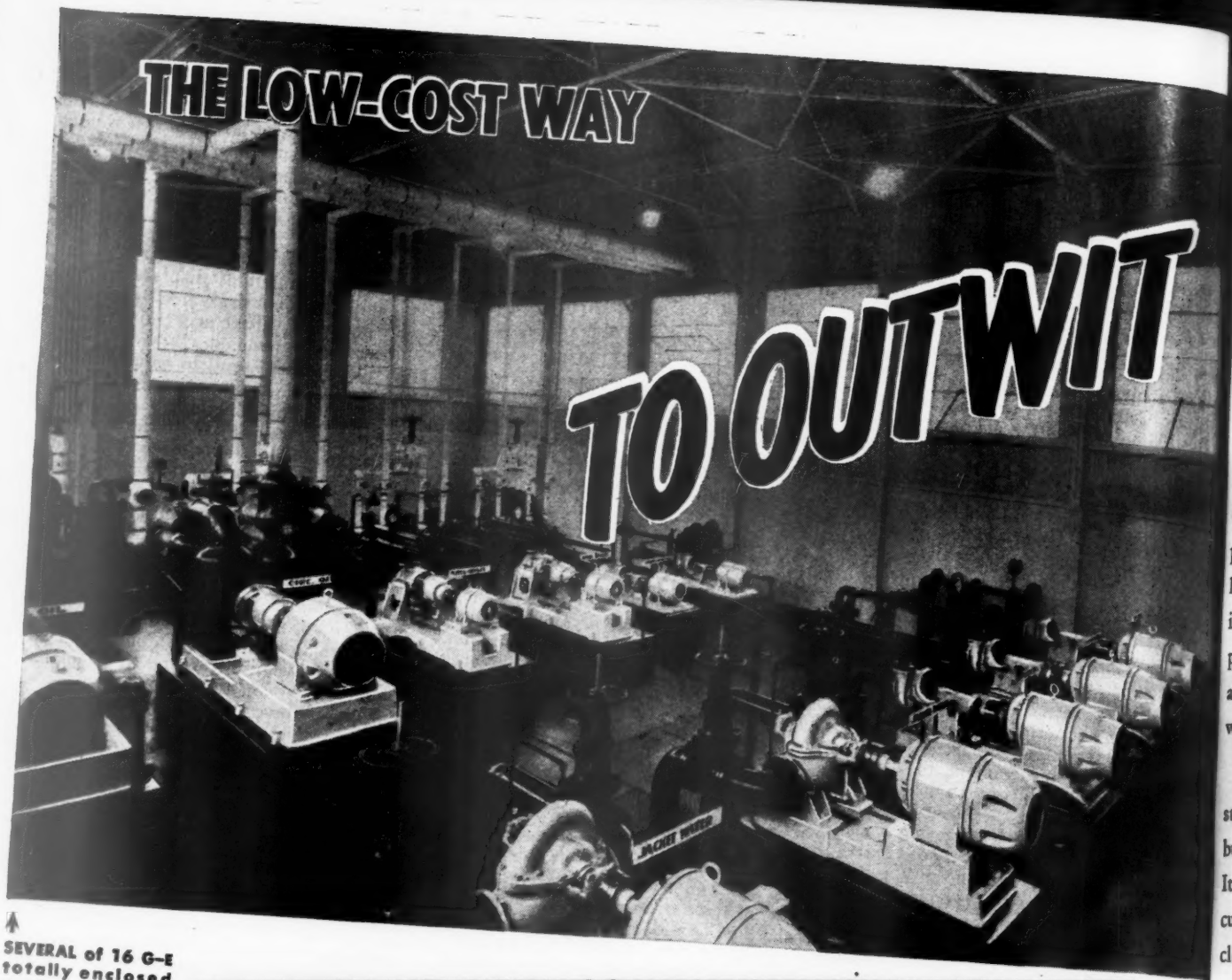
● **Crest of Weber sand is about minus 231 ft.** The subsurface structure as contoured on top of the Weber sandstone appears to conform very well with the surface structure. The highest well on the Weber sand thus far drilled in the Rangely field has a datum of minus 231 ft. subsea, whereas the lowest well 1¾ miles north has a datum of minus 761 ft. The average surface elevation in the field is from 5500 to 5400 ft. above sea level.

From AAPG 1941 Symposium on future oil provinces.



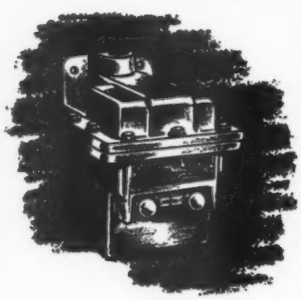
UINTA BASIN, UTAH AND COLORADO

THE LOW-COST WAY TO OUTWIT

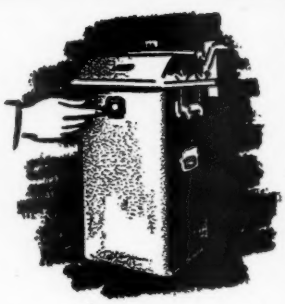


SEVERAL of 16 G-E totally enclosed motors for Class I, Group D, locations driving pumps in a Texas condensate-recovery and re-pressuring plant.

Air-break combination starter for Class I, Group D, locations. Combines air circuit breaker and magnetic starter in one compact unit. Made of cast, high-strength alloy, and having accurately ground, tight-fitting flanges, these starters can withstand internal explosions and prevent the escape of hot gases.



Push-button station for corrosive and hazardous-gas locations. All contacts operate under oil. Entire unit is enclosed in a cast-iron case which is specially finished to withstand acid fumes, alkali dust, or exposed outdoor service.



Oil-immersed combination starter for Class I, Group D, locations. All contacts are at least six inches under oil. Easy-to-read indicator provides safety check on oil level. Extra-tough exterior finish provides extra protection from corrosion caused by chemical fumes or exposure to weather.

GE

MOTORS AND CONTROL

For Hazardous Areas

Buy all the BONDS you can—and keep all you buy

EXPLOSION HAZARDS

YOU SAVE ON ENGINEERING TIME, CONSTRUCTION COSTS, AND MAINTENANCE WHEN YOU LET G.E. HELP YOU APPLY THE *RIGHT* EXPLOSION-PROOF MOTORS AND CONTROLS . . . . .

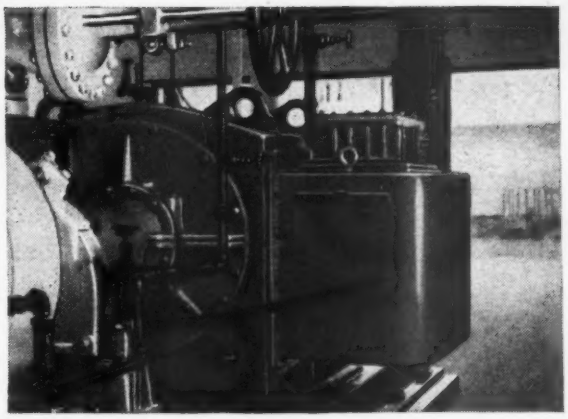
●In your plans to re-align your refinery for competitive, peacetime production, have you considered how you can cut the cost of supplying drive power in hazardous areas? Full utilization of G-E explosion-proof motors and control, wisely applied with the aid of G-E engineers, may well mean savings that will look big when competition gets keen.

It will mean savings in engineering time and construction costs, because you eliminate the need for building special vaults to isolate motors and control. It will mean less maintenance, because you avoid cumbersome remote drives, and because totally enclosed electric equipment is inherently less subject to trouble. It will mean lower insurance costs, because your plant will have the best in electrical safety.

General Electric has the most complete line of motors and control specially designed for refinery service. You'll also find expert assistance in selecting motors and control which best combine economy and safety on your jobs. G-E engineers specializing in refinery applications are at your service. Call on them now. *General Electric Company, Schenectady 5, N. Y.*

* * *

Free—28 pages of help. A new G-E book, "Motors and Control for Hazardous Locations," outlines what the different hazard classifications are, discusses the electrical aspects of explosion hazards, and shows you how to outwit them. Your copy is ready; just ask for GEA-4131.



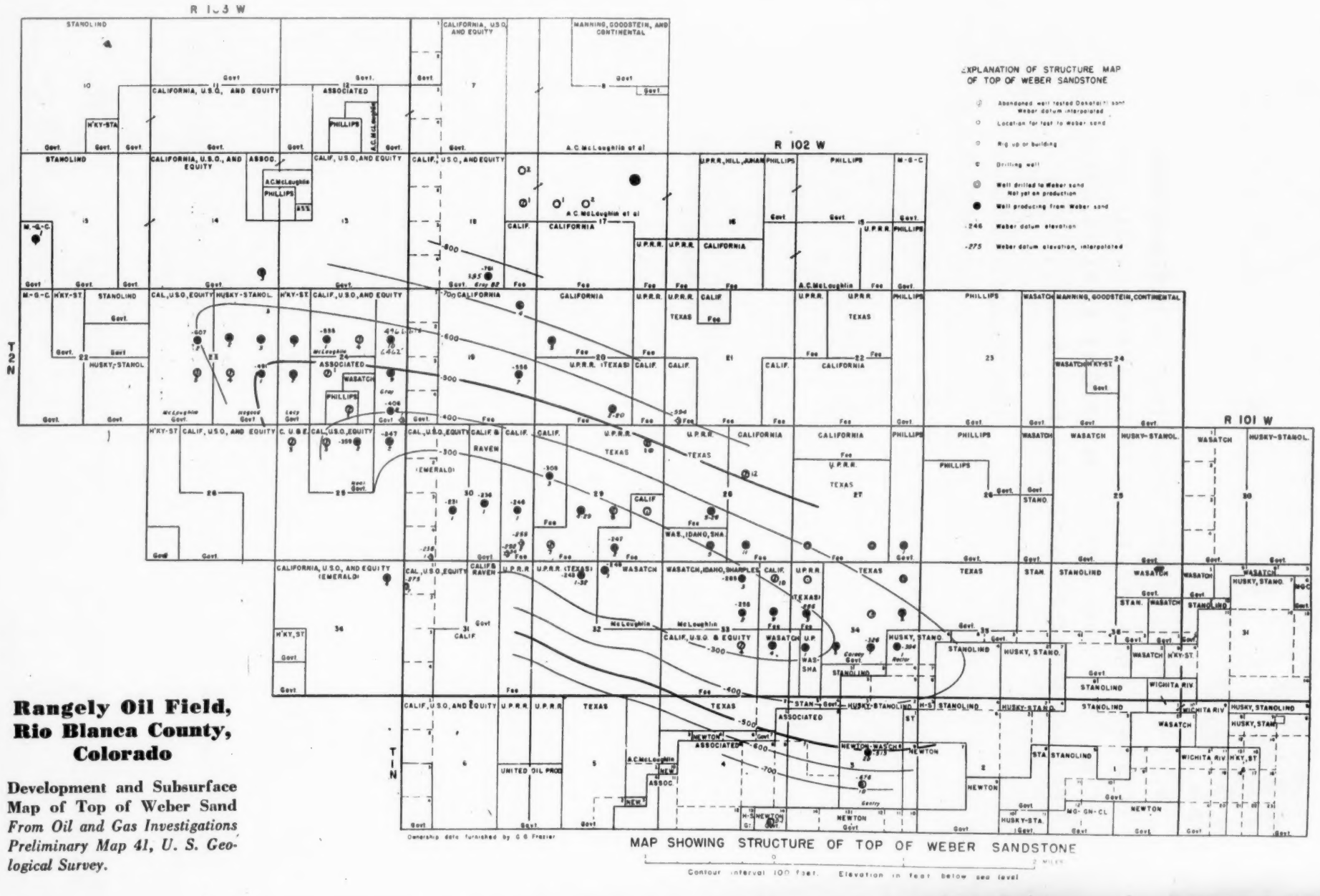
INERT-GAS-FILLED MOTORS

like the one shown above, have proved particularly useful in hazardous-area applications calling for motors of 400 hp or more. These motors are furnished with special enclosures and auxiliary equipment which maintain an atmosphere of carbon dioxide, under slight pressure, in the motor. The positive pressure prevents entry of hazardous gas, although the enclosure is sufficiently tight to prevent excessive leakage of CO_2. Make-up requirements are very small.

The G-E motor shown here, rated 1000 hp at 3000 rpm, drives a hot-oil charging pump in a California refinery.

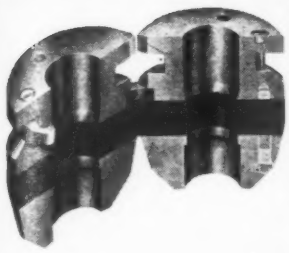
GENERAL ELECTRIC

654-38-152


R 103 W
R 102 W
R 101 W
T 2 N
T 1 N
EXPLANATION OF STRUCTURE MAP OF TOP OF WEBER SANDSTONE
Abandoned well tested Dakota(?) sand Weber datum interpolated
Location for test to Weber sand
Rig up or building
Drilling well
Well drilled to Weber sand Not yet on production
Well producing from Weber sand
-246 Weber datum elevation
-275 Weber datum elevation, interpolated
Ownership data furnished by G. B. Frazier
MAP SHOWING STRUCTURE OF TOP OF WEBER SANDSTONE
Contour interval 100 feet. Elevation in feet below sea level

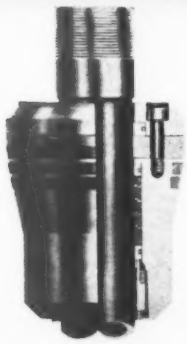
Rangely Oil Field, Rio Blanca County, Colorado

Development and Subsurface Map of Top of Weber Sand
From Oil and Gas Investigations Preliminary Map 41, U. S. Geological Survey.



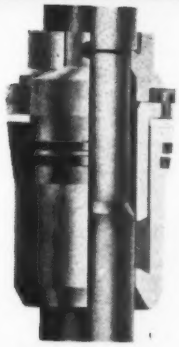
AG (ALK)

Used in completions where a polish joint hanger would otherwise be applied, this hanger eliminates the polish joint, since a seal can be effected on any joint of tubing. It can also be used as a blowout preventer.



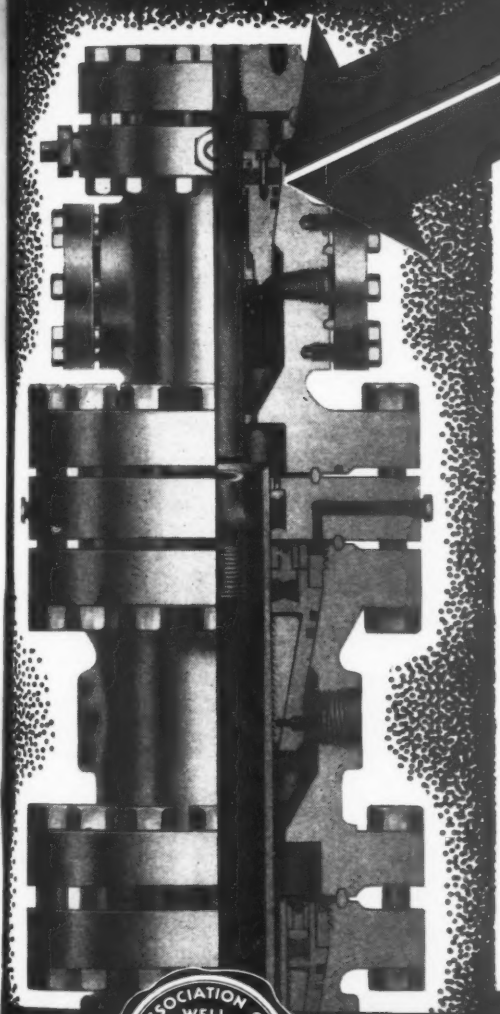
AD-1 (AFB-3)

Polish Joint Type which incorporates an additional means of sealing with tubing head lock screws.



AF (ASTM)

Permits running and landing of tubing through assembled christmas tree. This hanger is designed to permit any method of well completion.



Three New McEVOY Tubing Hangers

Adding even greater versatility to the range of McEvoy wellhead equipment are the three new tubing hangers shown above.

Type AG, interchangeable with other type A hangers, provides an effective seal without the use of polished tubing. Tubing may be safely moved through the hanger, for a length of one joint, under pressure.

Type AD-1 is a modification of the popular McEvoy AFB hanger in which the threaded gland has been moved to the bottom of the housing and a synthetic packing element added in the top to provide additional seal.

Type AF permits washing in and completion of well under full pressure control, and allows well completion of any type or combination of types.

A wide variety of other hangers is available for special purposes. Consult McEvoy on all your completion problems.

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SOUTH AMERICAN FIELD REPRESENTATIVE

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On the projected surface geology, the highest well referred to above is within the 7200-ft. contour and the lowest well is on the 6750-ft. contour. Therefore, the amount of surface dip between these two wells is 450 ft. whereas the subsurface dip is 530 ft., indicating that the structural dip may increase with depth.

The deepest well drilled in the Rangely field is the discovery well, the California Co. No. 1 Raven, which reached a total depth of 7173 ft. This well drilled a normal section and began in Upper Cretaceous marine shale and stopped in Pennsylvania sandstone. The records of this well and of other wells in and just outside the area indicate that the Paleozoic section is composed largely of thick continental sandstone and shale, marine limestone, and some local evaporites; that Mesozoic beds consist largely of continental sandstone and shale at the top and bottom with intervening marine shale; and that the Tertiary section is composed of continental sandstone and shale.

The average gravity of the oil produced from the Weber sandstone is 33 deg. and the sulphur content is 0.68 per cent.

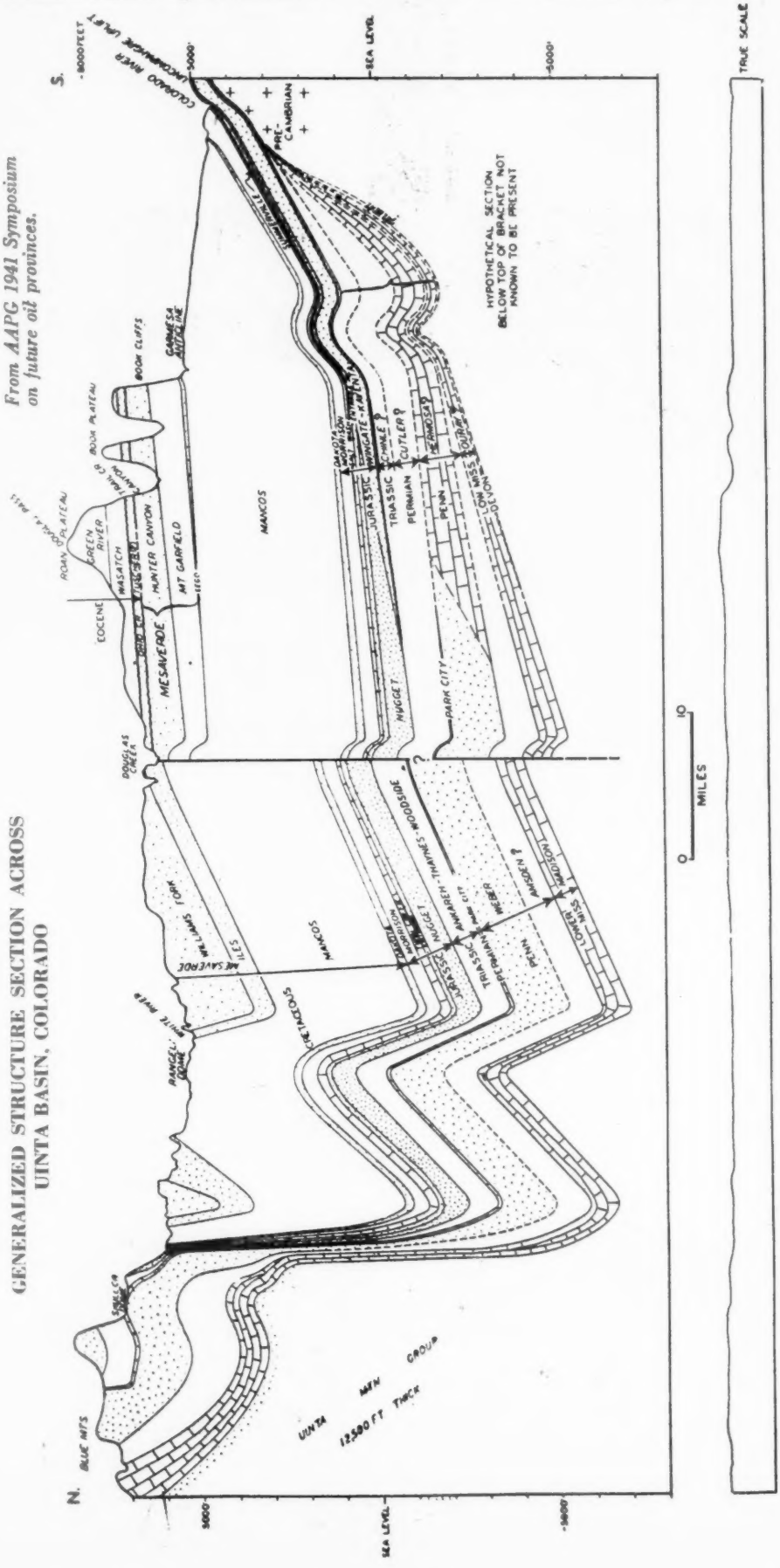
● **Oil sands in upper 600 ft. of Weber.** The upper 300 ft. of the Weber sandstone consists of fine to very fine grained gray to buff colored sandstone containing three beds, 10 to 15 ft. thick, of shaly micaceous red sandstone. Parts of the entire sequence are limey. The lower 1150 ft. is similar to the top 300 ft. with an increase in red beds downward. The several oil-bearing beds are buff colored and occur in the upper part of the section between 5704 and 6320 ft.

To date no well has reached the water table, but is believed that it may be at minus 1300 ft. subsea. If this conjecture proves correct, the Rangely field will have more than 1000 ft. of subsurface closure above the water table.

● **Field may produce 375,000,000 bbl.** The ultimate recovery per acre is also a matter of conjecture. It is conservatively estimated, however, that the average recovery will be between 15,000 and 20,000 bbl. per acre. It appears that at least 22,000 acres will be found productive, and assuming an estimated average recovery per acre of 17,500 bbl. as a minimum, the Rangely field has at the least a reserve of 375,000,000 bbl.

The wells are drilled on 40-acre spacing. The price per bbl. ranges from 75 cents for crude below 21 deg. API gravity to $1.15 a bbl. for crude of 40 deg. API gravity or above.

● **New 10-in. pipe line outlet completed.** When the Rangely field began to appear as a major oil reserve, the Stanolind Pipe Line Company constructed a 10-in. pipe line from the field to their station at Wamsutter, Wyoming, and also a gathering system in the field. The oil is being run to the Utah Oil Refining Company. Shipments began through the line on October 3, 1945, and runs average about 12,500 bbl. a day at present.



GENERALIZED STRUCTURE SECTION ACROSS UINTA BASIN, COLORADO

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3. "Future Oil Provinces of the United States and Canada," American Association of Petroleum Geologists paper.
4. "Geology of the Rangely Oil District, Rio Blanca County, Colorado," U.S.G.S. Bull. 350, 1908.
5. "Coal Fields of Northwestern Colorado and Northeastern Utah," U.S.G.S. Bull. 415, 1910.

★ ★ ★

In the Beginning . . .

The Drake Well . . . Christmas 1859

▲To our many friends everywhere ▲we extend our most sincere

▲wishes for a Merry Christmas ▲a joyous and prosperous New Year

▲and happiness throughout all the years to come

CONTINENTAL

SERVING THE OIL AND GAS INDUSTRIES

LOS ANGELES NOMADS HEAR WORLD TRAVELERS

THE November meeting of the Los Angeles Nomads, held as usual in the Rainbow Isle at the Mayfair Hotel, marked the return from South America of the Smith boys—prexy Elmer and prexy-once-removed Roland. It was the first time in many weeks that Elmer Smith had exercised his office, but Deputy Hi Cassidy had kept the caliber of the meetings at a high level and this accidental homecoming seance was quite up to his usual standard.

The meeting opened with the introduction of a considerable number of foreign and domestic guests, among whom the following should perhaps be especially mentioned: Mike H. Bush, American Overseas Petroleum Company, Ltd., Sumatra; Charles M. LaMar, Barnsdall South American Corporation, Barcelona, Venezuela; Hobart LaMar, formerly New Zealand Petroleum Company; Clarence Ochs, Ecuadorian Oilfields Ltd., Ecuador; A. W. Rothrock, Colombian Petroleum Company, Bogota, Colombia; Harry Shepherd, Angle-Ecuadorian Oilfields, Ltd., Ecuador; Earl H. Cochran, visiting member from Tulsa, Oklahoma; Charles Schneider, Tide Water Associated, San Francisco; George O. Suman, Tide Water Associated, Bakersfield, California.

Then came the initiation of one Alvin "Dutch" Zwerneman of the Axelson Manufacturing Company who successfully combated a furious assault on his integrity and good name and was eventually inducted into regular membership. In this ceremony Hi Cassidy was the lawyer for the prosecution and managed to build up what seemed to be an airtight case against the accused with all the persistence and skill of a district attorney. In his own defense, however, Dutch did a masterful job and there wasn't a dissenting voice, not ever from the D.A., when he was finally voted eligible and admitted to the inner shrine.

The program for the evening was a two-part affair, first featuring Nelson Pringle, news analyst and radio commentator from CBS, in an interesting dissertation on affairs in the Philippines. The willful and wanton destruction of life and property by the invading Japs was described in all its sordid detail, and to complete the story, Pringle exhibited technicolor films of the ruins of Manila. The speaker is a dynamic individual, thoroughly familiar with all factors affecting existence in the Philippines, and he presented a highly illuminating picture of the devastation that had been visited on the islands and the steps that would be required to restore some semblance of normal living to the long-suffering inhabitants of the islands.

The concluding speaker was Hugh R. VanWegenen, independent mining engineer, who outlined a remarkable wartime experience in which he was engaged by the United States government to find scarce but very essential minerals. His assignments took him first to Australia, then back to Washington, and finally to Southeast Africa. The excitement of the treks into the interior to find sources of supply were only one phase of an intriguing adventure in which the ultimate transport of equipment and supplies presented innumerable obstacles. VanWegenen told an interesting story in an interesting way and his recital was thoroughly enjoyed. It is something of a coincidence that both speakers had had occasion to consult with General Douglas MacArthur.

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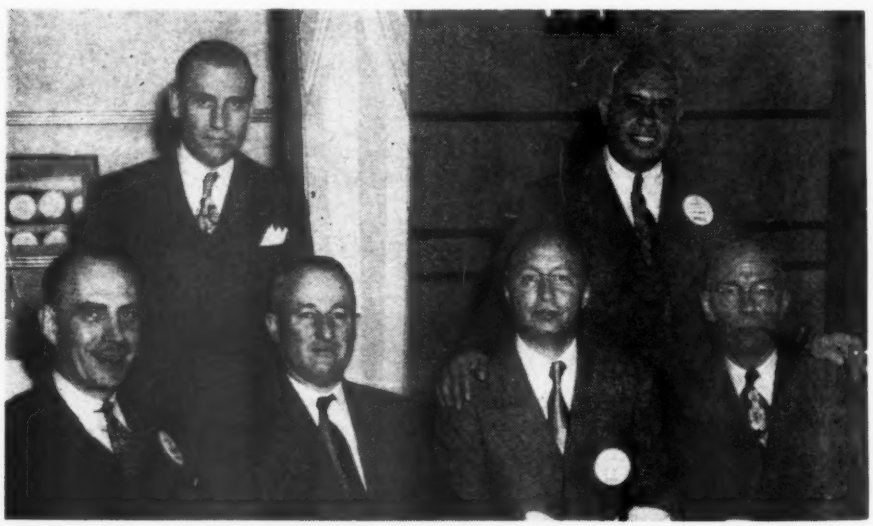

Among those who attended the November meeting of the Los Angeles Nomads are the men pictured here. Above, standing from left to right are: Frank V. Long, The Vapor Recovery Systems Company; J. J. Siegel, Kobe, Inc. Sitting: H. K. Browning, Kobe, Inc.; George O. Suman, Tide Water Associated Oil Company, Bakersfield; Reed O'Neil, Reed Roller Bit Company; C. Schneider, Tide Water Associated Oil Company, San Francisco.

At the left are: A. W. Rothrock, Colombia Petroleum Company, Cucuta, Colombia; L. A. "Frenchy" Thomas, Thomas Well Servicing Company, Trinidad; Clarence Ochs, Ecuadorian Oil Fields, Ltd., Guayaquil.

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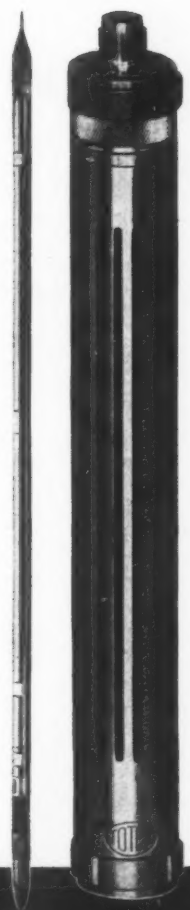
"Ben, when you started this well, you used a Totco Recorder and Controlled Vertical Drilling Methods because you know that anyone can drill wells straighter and quicker and cheaper that way. Your own records prove it. But you got into trouble because you stopped using the Totco.

"See there . . . first 2300 feet of hole O.K. Frequent Totco readings; never more than 1° off. But then you made a mistake, Ben. You made 800 feet of hole without bothering to take a Totco reading . . . and right there your well got away from you. That change in formation threw you off, and you didn't find it out in time. By the time you backed up, whipstocked her, and started to redrill, you'd lost pretty nearly 5 days, and used about 7 bits more than necessary. You can figure out for yourself how much that cost.

"I know you won't make that mistake again. Next well, stick with the Totco and Controlled Vertical Drilling Methods, and you won't have trouble. So long, Ben—it's my tour."

HERE ARE BEN'S FIGURES . . .



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FIELD SAFETY PROGRAM DEVELOPED BY AMERICAN ASSOCIATION OF OILWELL DRILLING CONTRACTORS

SAFETY of drilling crews is receiving greater planning and direction from American Association of Oilwell Drilling Contractors.

Three projects emphasize this important phase of every contractor's drilling program. First, the Insurance and Safety Committee of the AAODC, December 4, sponsored a Safety Conference at the Baker Hotel, Dallas, Texas. Second, the contractors have launched a monthly bulletin, "Safety Hints on Drilling," which publishes safety topics and reports from the safety field program. Third, the association has released a book, "Safety Manual for Rotary Drilling and Procedure for Operating Field Safety Program."

The one-day conference was called by William Broadhurst, chairman of the Insurance and Safety Committee and a comprehensive program was given.

J. Doyle Settle, AAODC committee secretary, presided at the morning session. A talk on "the drilling contractor's need for a uniform, practical field program" was made by Howard P. Holmes of Two-States Drilling Company. A. A. Munsch, U. S. Bureau of Mines, Bartlesville, Oklahoma, gave an outline of the thirty minute field safety program.

Three contractors gave their personal experience of the safety program in the field. They were Sam King, Kerlyn Oil Company, Oklahoma City; J. F. Postelle, contractor of Odessa, Texas, and K. B. Knox, K. B. Knox Drilling Company, Houston. Broadhurst who is vice president of Helmerich and Payne, Inc., Tulsa, explained the Insurance and Safety Committe's plan for sponsoring a field safety program.

The afternoon discussion was directed by E. L. Williams, director of industrial extension service, Texas A. & M. College. Subjects that were discussed were: Agreement on Basis Uniform Program, How to Place the Program in Operation, How to Keep the Interest Alive, and How to Disseminate the Information and Results Obtained.

The second project of the association, the monthly bulletin, has already become popular with the members. Extra copies are sent free to member-contractors upon request. The November issue stated that 113 companies had already requested additional copies to place on their rigs.

Reports from the field carried in the bulletin are listed under topical subjects, such as, "Eye Protection," "Tearing Down Rigs," "Hand Tools," etc. In addition subjects on the safety program are discussed in each bulletin. Good Housekeeping, Good Health during the Winter Months, Organize and Plan your Work, etc. are some of the items covered.

The bulletin was begun when the 30-Minute Weekly Safety Program was launched the latter part of February of this year on an experimental basis. Results of the program were encouraging enough to continue the work more extensively.

The Safety Manual can be purchased for $1.50 per copy through the AAODC, 1408-10 Gulf States Bldg., Dallas 1, Texas. Principal divisions deal with: Safety Drilling Practices, Rigging Up, Operation, Safety Field Program, and Basic Duties of Rotary Crew Members. The purpose of the manual is to attempt to provide for the rotary drilling industry a guide of recognized safety practices that, if followed by drilling crews will materially reduce the number of costly accidents occurring in rotary drilling operations.

The introduction points out that good safety practices are developed largely by drillers, who pass the procedures on to their crews. So far little has been set down in writing to disseminate the practices to new crew members or to standardize methods.

Besides the collection of safety methods that have proved valuable in actual experience, the manual carries suggested forms that may be used to advance the safety program. These include forms for toolpusher's check sheet for safety program, accident report form, form for driller's monthly safety drilling report and form for employment application and medical examination. There is also a copy of the weekly report form that is filled by the drilling companies who join the 30-minute weekly safety program of the U. S. Bureau of Mines and AAODC.

FOUR fundamentals are listed as necessary to top safety performance. They are as follows:

1. Proper management attitude. Management must be intensely safety minded. The prevention of injuries must continually be a part of the day-by-day thought and action of each drilling contractor and his supervisory force.

2. Elimination of physical hazards. Their discovery and elimination to the maximum practicable degree must be accepted as fundamental to good safety practices.

3. Control of work habits and practices. This control is also fundamental. It must not, however, be considered a substitute for proper attention to physical hazards.

4. Organization for safety. Regardless of the form this organization may take, the purpose to be accomplished is the development and maintenance of effective teamwork for safety throughout the entire personnel, a joint effort to eliminate injuries.

Listed as the more important activities that the drilling contractor should undertake to prevent accidents are:

1. Provide safe drilling equipment and tools.

2. Safeguard all machinery.

3. Place no new machinery or equipment in operation unless full attention has been paid to its safety and crews trained to use it.

4. Plan and arrange all drilling operations with careful attention to safety.

5. Maintain a system of rig, equipment and tool inspection to discover correctible hazards.

6. Maintain safety minded supervisors.

7. Train, educate, and stimulate its employees to follow safe methods of work and to take a sincere interest in the safety of themselves and their fellow workers.

8. Investigate each and every accident to determine how best to prevent a recurrence.

9. Make full and prompt report to the proper authorities of all cases of injury.

The entire program presents an aggressive movement by management to look after the safety of all employees to the best of their ability.

Contract drilling has had many difficulties in developing safety methods and, in the past, work along this line has been pushed aside for expediency. Safety is, however, a common problem and one that can be met with standardized procedure and intensive training.

REFERENCES used in developing the safety program are: "Safety Practices in Rotary Drilling," Robert C. Sharp, petroleum engineer, Los Angeles, California; "Rotary Drilling," API Accident Prevention Manual No. 10, API, New York; "Safety Subjects," United States Department of Labor, Washington, D. C.; "API Safety Code for Oil Fields," API, New York; Bureau of Mines Information Circulars No. 7329, and 6938, Washington, D. C.; "Toolpusher's Manual, Organization and Duties," Safety Section, Kerlyn Oil Company, Oklahoma City; and "Safety Rules and Regulations Covering Rotary Drilling," Associated Indemnity Corporation. ★ ★ ★

Millions of boys home or on their way...the sorrow of absence replaced by the joy of reunion in millions of hearts . . . all the world at peace—truly, we have much to be thankful for this Christmas. May you and yours enjoy a full measure of its happiness. Gaso Pump & Burner Mfg. Co. . . . Tulsa, Oklahoma

APPLICATION OF LABORATORY DATA ON PHASE BEHAVIOR TO EVALUATION OF CONDENSATE RESERVES

By **E. W. McALLISTER,** *Chief Engineer*

Western Gulf Oil Company

WITH the recognition of the phenomenon of retrograde condensation, the petroleum engineer has been faced with a new problem in estimating petroleum reserves in high pressure condensate or distillate type reservoirs. In addition to the reserves in place, it has been necessary to estimate the additional recovery of products to be expected from this type reservoir when produced under a pressure maintenance or cycling program over that which would be recovered under a normal pressure depletion program. Also, whether or not the increased recovery would economically justify the additional expenditure required for high pressure equipment and increased operating costs of a cycling program.

Although the phenomenon of retrograde condensation has been recognized in laboratory work for many years, there is still considerable lack of the specific information required properly to estimate the petroleum products that would be recovered from a condensate pool produced by straight pressure depletion. This is due to the lack of laboratory equipment suitable for running condensation or phase behavior experiments on samples involving a change in composition with decrease in pressure. This experiment involves withdrawing portions of the sample in the gas phase, causing each increment of pressure decrease and determining the composition of the portions of sample withdrawn and remaining. At present, nearly all laboratories are equipped to run phase behavior experiments involving no change in composition of the sample and showing only the indicated relative volume of liquid condensed with change in pressure and without determining the composition of the liquid so condensed. Such data are suitable only for determining the products to be recovered at the dew point pressure or above, with an indication of the magnitude of the rate of liquid condensation that may occur in the reservoir with pressure drop in the retrograde region.

For example, in Fig. 1 are condensation curves for samples taken from 2 different condensate fields plotted from data from experiments run involving no change in composition of the samples. These curves are the customary type run in phase behavior experiments. The scale showing "Liquid Formation Volume—Per Cent" indicates the relative amount of liquid condensed in the apparatus at the corresponding pressure on the basis that the volume of the liquid phase of the sample originally contained in the apparatus at standard conditions was equal to 1.00 or 100 per cent. By way of explanation, it will be noted the relative liquid volume as indicated by the curves does not approach 1.00 or 100 per cent at zero pressure. This is due to the experiments being run at reservoir temperature, which in case of the curves in question is considerably above the standard temperature of 60°F. at which the original volume of the liquid samples were determined. As a consequence, lighter fractions originally contained in the liquid samples are vaporized due to the elevated temperatures.

*Presented before California Natural Gasoline Association, Los Angeles, October 12, 1945.

FIG. 1

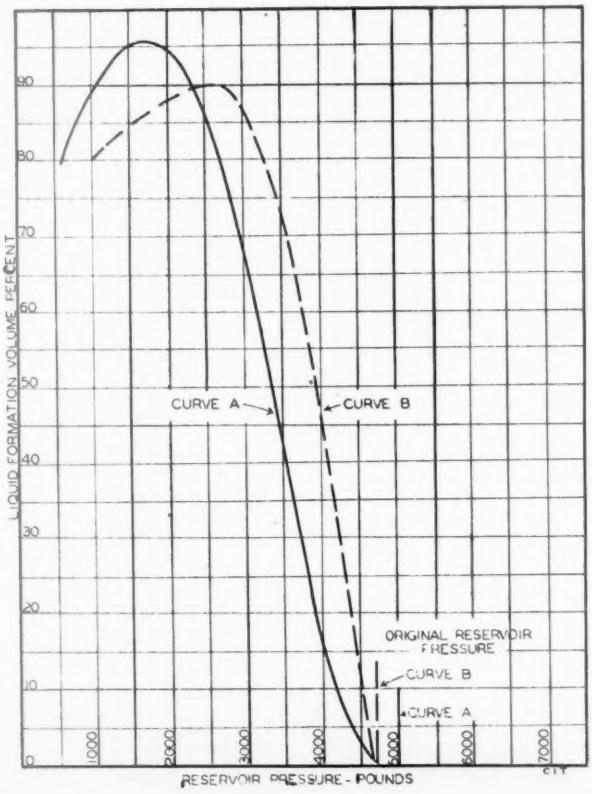
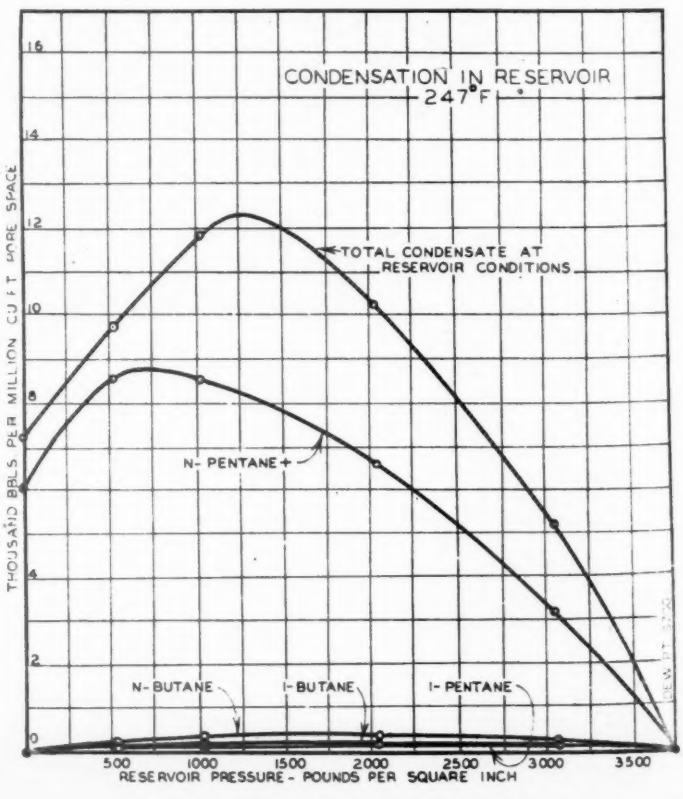


FIG. 2



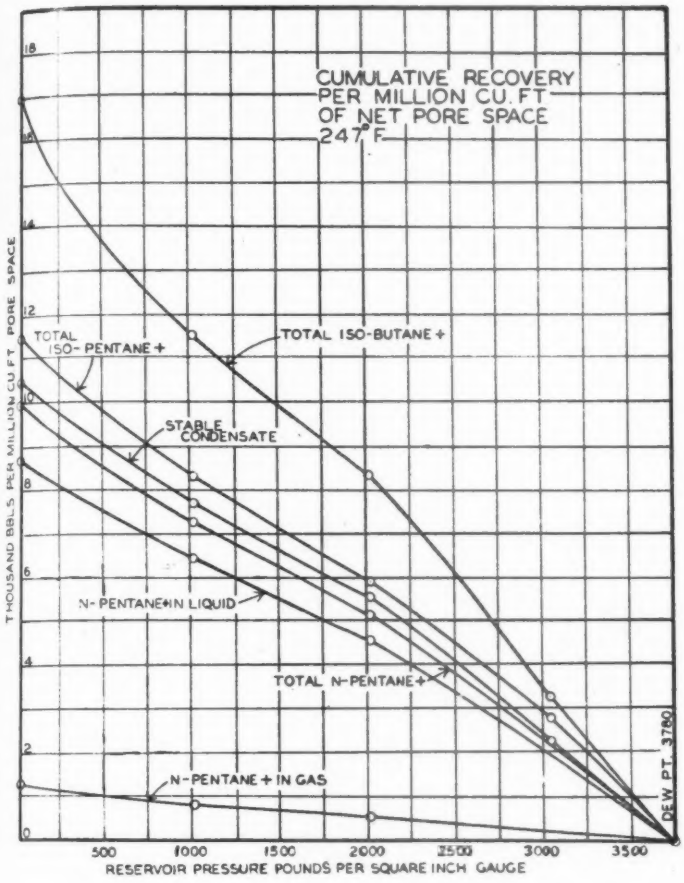


FIG. 3

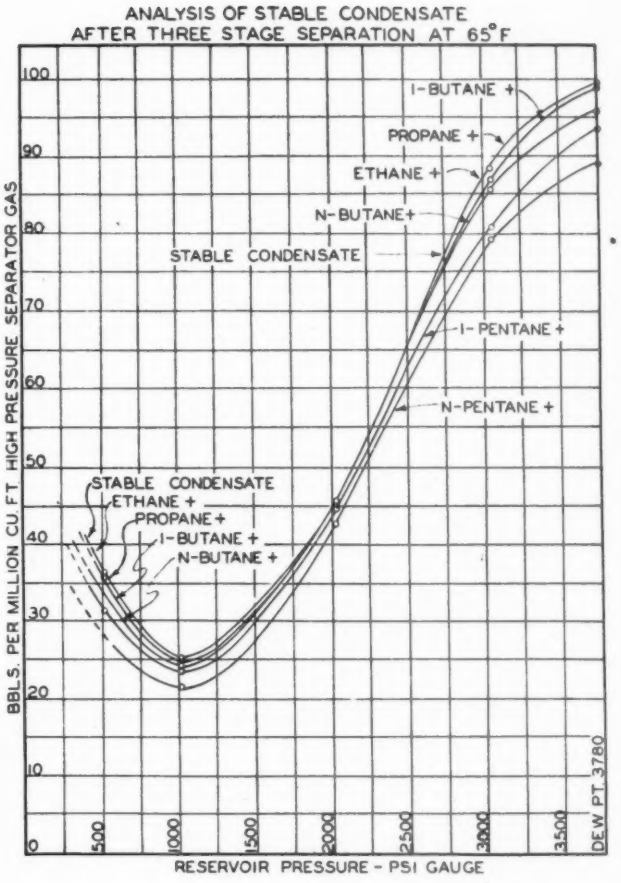


FIG. 4

From these curves are determined the dew point pressure at which condensation begins with the attendant loss of heavier hydrocarbons in the reservoir. Also indicated by the general shape and slope of the curves in relation to each other are the relative rates of condensation that occur below the dew point; that is, Curve A indicates a less rapid rate of condensation immediately below the dew point than does Curve B*. This coupled with the fact that the dew point of Curve A is approximately 300 lb. per sq. in. below its original reservoir pressure indicates a lower percentage of increased recovery for a pressure maintenance program than does Curve B.

The apparent liquid condensation below the dew point as indicated by both curves is misleading, however, for the volume of the condensed liquid as shown consists in part of lighter hydrocarbons (methane, ethane, etc.,) in solution due to pressure, which would not be recovered as a liquid product under atmospheric conditions. Curve A, for example, indicates a liquid condensation, in relation to the original liquid sample, of 16.5 per cent at 4000 lb. per sq. in. pressure of which only approximately 55 per cent is recoverable liquid. In other words, rather than 16.5 per cent of the original liquid volume condensing at 4000 lb. per sq. in., representing a possible loss in the formation, only about 9 per cent of the original liquid sample is condensed. It can readily be seen from this comparison that the loss of heavier hydrocarbons by condensation in the reservoir, as determined from curves such as those in Fig. 1, would not be representative of the loss that would occur in actual practice.

The possible magnitude of this difference is indicated by the curves in Fig. 2†. These curves are plotted from data resulting from an experiment run on samples from a field other than those sampled for the experiments previously discussed. The curves in Fig. 2 show the condensation of isobutane, normal butane, isopentane, and normal pentane and less volatile fractions with pressure drop in addition to a total condensation curve similar to those in Fig. 1. In the case of the experiment for the curves in Fig. 2, however, the composition of the sample was changed continually by withdrawing a portion of the sample remaining in the gas phase for each decrease in pressure. This is more nearly representative of producing a field by pressure depletion than are the experiments run for obtaining the curves in Fig. 1, in which the composition of the samples were maintained constant and the volumes varied to obtain changes in pressure.

It will be noted in Fig. 2 that the isobutane, normal butane, and isopentane fractions are nearly or completely vaporized at zero pressure. Thus, if the reservoir pressure could be completely depleted, there would be very little, if any, loss of these fractions due to condensation within the reservoir and consequently no benefits would be derived from a

*"Volumetric and Phase Behavior of Oil and Gas Paloma Field," by R. H. Olds, B. H. Sage, and W. N. Lacey. *AIME Tech. Pub. No. 1861.*

TABLE 1

Components	Hydrocarbons originally present in reservoir		Hydrocarbons recoverable			
			*Cycling with subsequent pressure depletion to 500-lb.		By pressure depletion to 500-lb.	
	Bbl. per MM. cu. ft. Pore space	Per cent	Bbl. per MM. cu. ft. Pore space	Per cent	Bbl. per MM. cu. ft. Pore space	Per cent
Isobutane +	23,650	100	19,240	81.4	13,680	57.8
n-Butane +	21,220	100	16,980	80.0	11,380	53.6
Isopentane +	18,710	100	14,850	79.4	9,770	52.2
n-Pentane +	17,490	100	13,710	78.4	8,600	49.2
†Condensate	17,460	100	14,430	82.7	.....	....

*Assuming 70 per cent of the reservoir cycled with a 10 per cent pressure drop during cycling period due to removal of liquid products and gas used as plant fuel.

†Unstabilized or raw condensate.

†Figs. 2, 3, and 4 and Table 1: Gulf Research and Development Company, Pittsburgh, Pennsylvania.

pressure maintenance program. In the case of the normal pentane and heavier hydrocarbons, the curve indicates these fractions do not completely vaporize at zero pressure and also the condensation of these fractions reaches a maximum at approximately 600 lb. per sq. in. This pressure is only slightly above the pressure range that is normally used in estimating the pressure remaining in a reservoir at abandonment. The difference between this latter curve and the curve showing total condensation, which includes methane, ethane, etc., will be noted.

The curves in Fig. 3, plotted from data obtained from the same experiments as the curves in Fig. 2, indicate the cumulative barrels of isobutane and heavier, isopentane and heavier, and normal pentane and heavier to be recovered per million cubic feet of pore space as a function of pressure. Assuming no repressuring effect from edgewater, the ordinates of these curves multiplied by the net pore space of the reservoir in millions of cubic feet will give directly the production of each product that can be expected by producing the field by pressure depletion to any reservoir pressure.

The curves in Fig. 4, also plotted from data from the same experiments as the curves in Figs. 2 and 3, show the number of barrels of each component in the stable condensate per million cubic feet of high pressure separator gas that will be produced at the various reservoir pressures. From these curves the amount of gas that would have to be handled for each barrel of condensate during any period of the life of the field under pressure depletion is indicated. That is, initially approximately 1,000,000 cu. ft. of gas would be handled with each 100 bbl. of stable condensate produced, whereas at the time the reservoir pressure has been depleted to 2000 lb. per sq. in. only 45 bbl. of condensate will be produced with each million cubic feet of gas. In other words, the gas-oil ratio has been more than doubled due to condensation of heavier hydrocarbons within the reservoir because of pressure drop.

The same data as presented in Figs. 2 and 3 are used to determine the volume of the recoverable hydrocarbons that may be expected under a cycling or pressure maintenance program.

As an example, assume 70 per cent of the reservoir may be cycled and the average reservoir pressure drop during this period, because of the extraction of liquid products and gas used as fuel, will be 10 per cent (400 lb. per sq. in.) resulting in a reservoir pressure of 3400 lb. per sq. in. From Fig. 2 it is indicated that approximately 5190 bbl. of normal pentane and heavier hydrocarbons per million cubic feet of pore space will be condensed or lost in the reservoir with this pressure reduction. Based on formation volume factors derived from the experiments, it is calculated 17,490 bbl. per million cubic feet of pore space of pentane and heavier hydrocarbons were originally in place. Deducting the 1590 bbl. lost by condensation from this figure and multiplying by 70 per cent gives a recovery of 11,130 bbl., from the 70 per cent of the area assumed to be cycled.

In the uncycled portion of the field, which will be produced subsequent to the cycling program by pressure depletion to 500 lb. per sq. in., Fig. 3 indicates a recovery of 8600 bbl. of normal pentane and heavier hydrocarbons per million cubic feet of pore space, which multiplied by 30 per cent gives a recovery of 2580 bbl. in the uncycled area. This is equal to a combined recovery from the total area of 13,710 bbl. of normal pentane and heavier hydrocarbons per million cubic feet of pore space or 78.4 per cent of the original hydrocarbons in place. As a matter of comparison under straight pressure depletion program, the recovery would have been 8600 bbl. or 49.2 per cent of the original hydrocarbons in place. Likewise, as shown in Table 1, the recovery of any hydrocarbon fraction or group of fractions may be calculated.

With these data, and knowing the size of the reservoir, the economics of whether to produce a field by pressure depletion or by cycling may be determined. Certain refinements, which may be made in the calculations to assist in evaluating the respective programs, have not been discussed herein, as they were not deemed essential in explaining the use of the basic data.

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WEST COAST GEOLOGISTS HOLD ANNUAL MEETING

THE two-day annual meeting of the American Association of Petroleum Geologists, Pacific Coast Section, at the Ambassador Hotel recently brought out some 400 geologists and near-geologists to hear an unusually fine assortment of papers on a wide range of subjects. With E. Robert Atwill, Union Oil Company, presiding at the opening session on Thursday morning, the meeting began with a paper by Frank S. Parker, Signal Oil and Gas Company, entitled "Results of California Exploration During the War."

The author designated his subject a continuation through the war period of the work that was originally begun by Roy Barnes and reported by him in the *AAPG Bulletin* of October, 1940, particular emphasis, however, being laid on discoveries during the first 9 months of 1945. The trends of geophysical activity, geological employment, and other related matters were discussed briefly, but no very definite conclusion was drawn except that while seismic exploration has fluctuated seasonally, it can be averaged down to a level trend.

Wildcat drilling as shown by the dry hole curve has increased and broken previous records both in 1943 and 1944. The lesser increase in number of currently active wildcats is ascribed to increased efficiency in shortening rigging-up and shut-down time, due to greater demands for rigs and crews. A clear correlation is shown between the number of wildcats drilled and the number of discoveries made. The less obvious correlation between geological employment and discoveries may be due to the lapse of time between the working out of a play and the drilling of it—in some cases 5 to 10 years. The increased demand for the price of dry gas is reflected in the increasing number of gas field discoveries.

New reserves, according to the author, have failed to keep pace with production. The latter reached a new high in 1944 of 311,000,000 bbl. and may reach 315,000,000 bbl. in 1945, the pace being maintained by expanded development drilling, the discovery of new pools, and the extension of old ones. By the end of the war, California reserves had declined only 185,000,000 bbl. from 3,533,000,000 in 1939 to 3,348,000,000 in January, 1945. The effect of Order M-68 on development drilling is marked by a slump whereas practically no effect can be noted on wildcat drilling. As intended that order provided materials to maintain the pace of exploration drilling at the expense of development drilling.

California discoveries apparently have come in steps of half a billion or more barrels addition to reserves every 8 or 10 years, coincidental with advances in finding technique. The present year, according to the record, should be the one for another such increase but it hasn't materialized to date. Parker estimated roughly 25,000,000 bbl. of oil as the reserves of the new fields, but with the data so far available declines to make an estimate of the new gas fields or of the new pools and extensions. He exhibited charts showing 20 wildcats to be successful out of 202 drilled. Of these only 16 will eventually be regarded as having found fields rather than extensions, and 5 of them are of doubtful commercial value. The greatest footage and number of wells were drilled on sub-surface work. The overall wildcat success was 10.2 per cent. New pool tests were 31 per cent successful and outposts 42 per cent successful. It appears that at the present rate 1945 will end with somewhat less wildcat footage but with a greater number of wells drilled. Other types of exploratory wells will exceed substantially 1944 both in footage and number.

Other papers delivered during this session were a presentation of data on the 27-B Pool at Buena Vista Hills, Taft, California, by Evan Burtner, Standard Oil Company of California, Taft, and a discussion of "Stratigraphic and Structural Problems of Southern Nevada and Western Arizona," by Chester R. Longwell, AAPG distinguished lecturer, Yale University, New Haven, Connecticut. Also of moment in this part of the program was the nomination of officers for the ensuing year, during which ceremony Glenn Bowes took charge of the proceedings.

After lunch, at which the national officers were introduced, the technical sessions were resumed under the chairmanship of James C. Kimble, General Petroleum Corporation, Bakersfield, and opened with a paper by J. S. Hollister, consulting geologist of Gaviota, California, entitled "Geology of Tierra Del Fuego, South America." This was a brief resume of the stratigraphy and structure of that part of southern Chile and pointed out the presence of a Cretaceous-Tertiary basin 20,000 ft. or more deep east of the main Cordillera, and it was suggested that a land mass lay to the west as well as one to the east of this basin during the late Mesozoic and Tertiary time. The author accompanied his talk with kodachrome slides of typical scenes in the areas described.

Thomas Clements of the University of Southern California, Los Angeles, fol-

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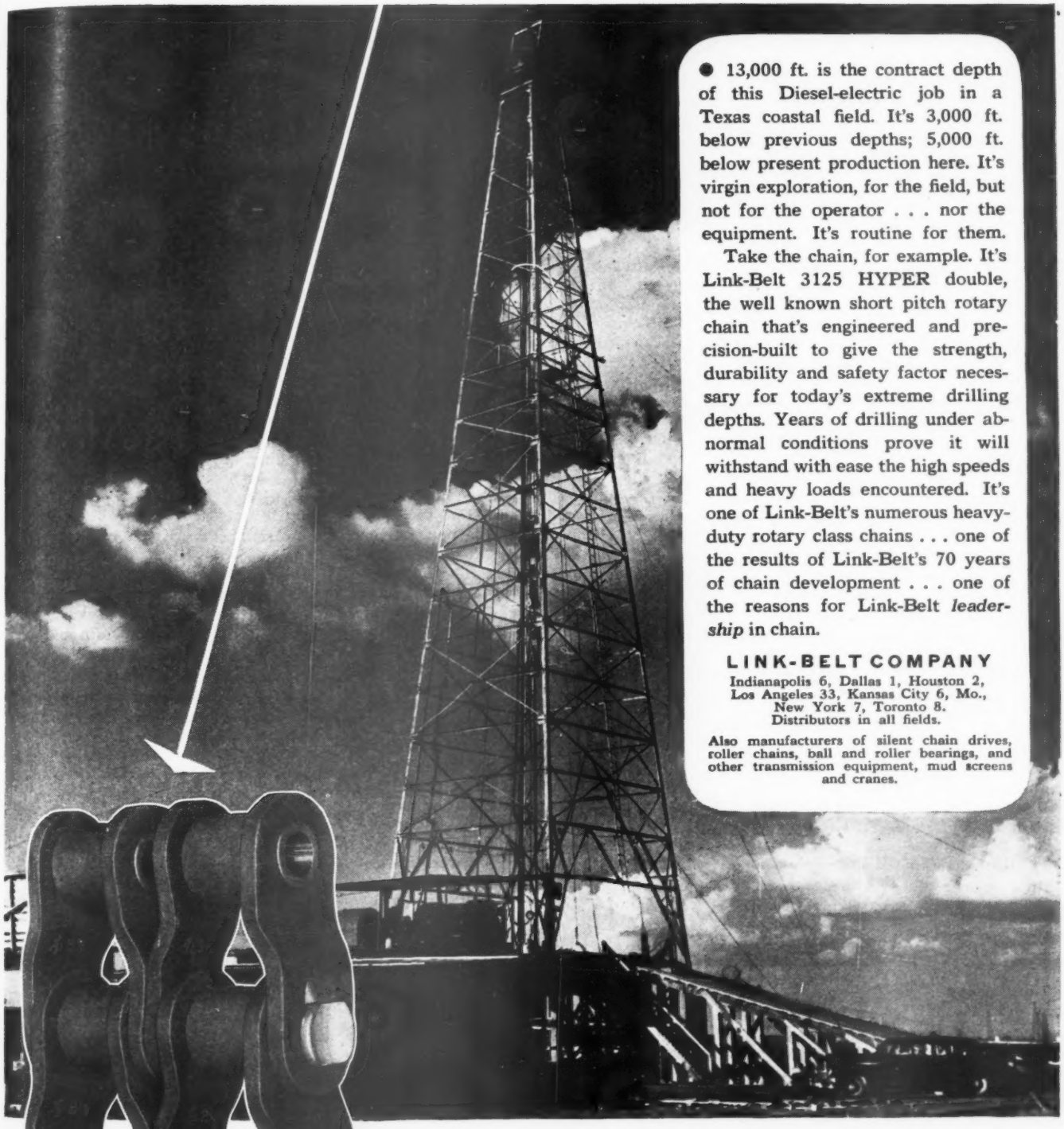

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lowed with a paper, "Stratigraphic Section East of Bogota, Colombia, South America," in which he recounted a geologic traverse made by him in 1939 along the road from Bogota to Villavicencio, some 122 kilometers. The purpose of the trip was to attempt correlation of the little-known east side of the Cordillera Oriental with the better formations of the Magdalena Valley on the west side of the mountains.

Rocks outcropping along the traverse are sedimentary and metamorphic and range in age from possible Cambrian to Pleistocene, only the Cretaceous rocks yielded abundant fossils. Igneous rocks reported to occur both to the north and south of the line of traverse were not found in this particular section, although the basal conglomerate of the Cretaceous contains fragments of granite. The author named the formations observed with their respective ages and finished with some general conclusions, as follows: The principal structural features are the Bogota fault, an overthrust to the west; the Caqueza fault, an overthrust to the east; the San Martin fault, normal, with the westerly block downthrown; and the Cientoquince fault, an overthrust to the east. In addition, the Guadalupe formation is folded into a large, gentle syncline, and all the rocks show a very great number of small folds.

Dr. R. I. Stirton of the University of California at Berkeley, presented an interesting discussion on "The First Oligocene Mammalian Fauna From Northern South America." This paper described fossil vertibrae remains found on the northwest limb of the San Jose anticline, south of the Rio Tetuan and approximately 10 kilometers northeast of Chaparral, Tolima, in the Upper Magdalena region of Colombia. They were discovered in a thin lens of bone breccia within a blue gray clay member (La Cira zone) of the Gualanday (Brazalosa) series. The type La Cira from the middle Magdalena was called Upper Oligocene by A. A. Oleson as based on a fresh water invertebrate fauna. The mammal remains from Chaparral indicate a relationship close to the Deseado Lower Oligocene of Argentina. The author also supplied a tentative faunal list.

Then came a report on "Recent Investigations by the Geological Survey of Alaska's Petroleum Possibilities," by John C. Reed, U.S.G.S., Washington, D. C., an abstract of which follows: The U.S.G.S., because of the national emergency, instituted detailed examinations in a number of areas that, on the basis of half a century of reconnaissance work, might be expected to contain petroleum. In 1944 these investigations were undertaken in 5 widely separated locations and similar investigations were continued in 1945.

The results indicated that three large areas appeared to be most promising—the Gulf of Alaska, the Alaska Peninsula - Cook Inlet area, and northern Alaska. In each of these regions are a number of structures or other indications favoring possible accumulation of petroleum and hence worthy of further investigation. In the Gulf of Alaska area the oil possibilities are confined to rocks of Tertiary age. Farther west in the Alaska Peninsula - Cook Inlet area, Jurassic rocks overlie a Triassic limestone that is presumed to be a possible source. In Northern Alaska, the Navy Department is exploring the oil possibilities of Naval Petroleum Reserve No. 4 that lies in an extensive tract underlain for the most part by gently folded Cretaceous rocks. The U.S.G.S. is aiding in the exploration program of the Navy. More information is required before an estimate in quantitative terms might be reached, but the author feels that the latent resources of this great northwestern territory present a challenge that the industry should not overlook.

The session concluded with a paper by Horace D. Thomas, University of Wyoming, Laramie, and Max L. Krueger, Union Oil Company, Laramie, Wyoming, on "Late Paleozoic and Early Mesozoic Strata of the Uinta Mountains, Utah." The authors point out that Triassic rocks rest unconformably on the Permian Park City formation, at the west end of the Uinta Mountains. From the base upward the Triassic rocks are: (1) Red Woodside shale, (2) marine Thaynes limestone, (3) Ankareh redbeds, and (4) a conglomerate and overlying sandstones and shales.

At the eastern end of the mountains, Woodside redbeds rest on the Pennsylvania Weber standstone. The lower part of the Woodside is the time equivalent of the Upper Park City (Phosphoria). The Woodside is cut by an unconformity above which lies a conglomerate.

The Jurassic formations of the western Uinta Mountains from base upward are: (1) Nugget sandstone, (2) Twin Creek limestone, (3) Preuss redbeds, (4) Stump sandstone, and (5) Morrison formation. Eastward along the mountains (1) Nugget sandstone per-

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MGR., HARVEY, LA.
H

sists but is called Navajo to the east, (2) the Twin Creek limestone intertongues with the Carmel redbeds, (3) the Preuss redbeds grade into the cross-bedded Entrada sandstone, (4) the Stump sandstone grades into Curtis shales and limestones, and (5) the Morrison thins and becomes less conglomeratic. At the eastern end of the Uinta Mountains the Carmel redbeds thin out so that the Navajo is directly overlain by the Entrada, forming a single cross-bedded sandstone unit.

Under the chairmanship of Rollin Eckis, Richfield Oil Corporation, Bakersfield, the Friday morning meeting featured "Notes on the Geology of the Deep Coles Levee Well, Kern County, California," by N. J. Taliaferro, University of California at Berkeley, and W. F. Barbat, Standard Oil Company of California, Taft. This was followed by "Notes on Rocky Mountain Thrust Faults" by Edward C. H. Lammers, Standard Oil Company, Los Angeles, a dissertation that discussed two types of low-angle thrust faults in the central Rockies. The faults along the Idaho-Wyoming border were formed when the exceptionally thick Paleozoic and Mesozoic strata of the Cordilleran geosyncline were intensely compressed during the Laramide revolution. Movement on these faults, which do not involve the crystalline rocks of the basement complex, is believed to have been dissipated at depth by shearing along bedding planes. The name "geosynclinal" thrust fault is proposed for faults of this type.

In contrast, the low-angle thrust faults of central Wyoming and southern Montana were produced by the further compression of large faulted blocks previously uplifted during an earlier stage of the Laramide revolution. The crystalline cores of these uplifts contributed large quantities of detritus to the Paleocene strata forming the foot-wall blocks of some of the thrusts. A study of the structure of the basement complex indicates that the present uplifts occupy the sites of pre-Cambrian mountain ranges. Hence this group of thrust faults borders areas that have been recurrently structurally positive throughout geologic time. The name "geanticlinal" thrust fault is proposed for thrust faults of this type.

"Terrestrial Dynamics," a lecture by Bailey Willis, AAPG distinguished lecturer, emritus professor of geology, Stanford University, was a topical presentation that created a great deal of interest and excitement. Dr. Willis stressed the need for a revision of geologic theories indicated by progress in physics and geology. We now know, he stated, that the earth has a molten core 4000 miles in diameter, which is covered by a shell 1800 miles thick—solid and mostly crystalline in character. There is also an outer crust roughly 20 to 30 miles thick. The effective forces operating throughout this structure are gravity or load pressure, heat, and atomic attractions and repulsions. The heat may be attributed to compression and radioactive disintegration of atoms, but probably not to survival from an originally molten globe. In the hypothesis offered it is regarded as mainly due to radioactive processes.

It is reasonable to assume that radioactive minerals exist in the core and are its principal source of heat. As the heat cannot escape the core must be heating up and growing at the expense of the mantle. The earth, thus, is growing hotter and not cooling. The boiling core emits gases and superheated liquids that bore into the mantle and form bubbles of magma. The bubbles rise by virtue of their buoyancy and boring activity. Their mineral composition changes by assimilation and the adjustment of mineral species to environment. Starting in the core as nickel iron and accessories, they emerge in the crust as basalt and granite.

The mechanics of the pressure in and around the bubble of magma give it the shape of a pear, biggest at the top. On approaching the surface this effect develops the tack-shaped batholith. The cover over such a batholith is likely to uplift, indicated at the surface by elevated plateaus and broad domes or elongated swells, and to metamorphism, which may produce lateral pressures. Under certain circumstances, the effect of lateral stress and strain in combination with magmatic heat may produce extensive horizontal intrusions some 20 miles below the surface. Such a one is thought to have been the mass under the Appalachian geosyncline during the Paleozoic era. To that mobile foundation may we attribute the sinking of the sediments and by a logical development of load stresses in combination with magmatic pressures we may explain the folding of the Appalachians, the outthrust of the Himalayas, and similar displacements.

Bubbles of igneous rock have risen to the surface at intervals during the last 2 billion years. They consist of two principal kinds, basalt and granite. They differ in fluidity or viscosity. The basalt reaches the surface and spreads out forming such features as ocean beds and plateaus. The granite lifts the surface without breaking through, causes lateral stresses and becomes the core of a mountain range. The possible mechanical effects are varied. We cannot reason from one orogeny to another without due consideration of the facts of unlike histories. The Appalachian mechanics will not explain the Rockies, the basin ranges, nor the Alps. Each orogeny is a problem in itself, but they all can be explained through a study of the reactions of the forces of gravity, magmatic intrusion, and atomic activity. The prolonged sequence of intrusions of the surface by magmatic bubbles is regarded as the source of the crust. The process is not finished and never can be because radioactive disintegration continues to heat the core. We may infer that the thinning mantle ultimately will disappear and the planet will become a star.

The Friday afternoon gathering, presided over by Homer J. Steiny, Tide Water Associated Oil Company, Los Angeles, opened with a paper on "Landslides - Ventura Avenue Oilfield," by Claude Leach and Henry H. Neel, Tide Water Associated Oil Company, Ventura. This was followed by an address by William Putnam, University of California at Los Angeles, wherein the speaker gave a very interesting insight into the methods by which geology became a valuable aid in the war effort, apart from its utilization as a mineral finding science. Actual examples of the applications in the Pacific theater seemed to indicate that the geologist has here an opportunity to widen the scope of his profession in a very specific and substantial way.

The windup of the technical sessions was an address by Mortimer Kline, Los Angeles attorney, entitled, "The Most Powerful Man in the World." Opening with a tribute to the work of PAW, Kline heartily subscribed to the oft repeated statement: "The oil job was the best job on the civilian front in Washington." Having delivered himself of some very eulogistic remarks, both on the organization and the industry, he then turned to a discussion of the Anglo-American Oil Agreement, with the present status and general ramifications of which he displayed an intimate acquaintance. He expressed the opinion that the pact in its present form is an important step toward a final agreement that would be acceptable both to Britain and the United States. Progress in this matter, he intimated, is highly important for many reasons, one of which is the desirability that the two countries institute a program for the joint development of the great petroleum resources of the Middle East.

Kline's "Most Powerful Man in the World," was Sir Henry Deterding, who has inspired more biographical literature than even John D. Rockefeller. The speaker went deeply into the life and accomplishments of this great industrialist, and recited the details of his exciting efforts to enlarge and extend the already large holdings of his company. In the course of these struggles he probably did more for the petroleum industry than any other known individual and certainly he has written a sterling chapter into the history of petroleum.

On Friday evening, the polysyllabic brigade brought their wives, daughters, and/or sweethearts to the Ambassador Embassy Room, and tripped the light fantastic enthusiastically in an effort to relieve the strain of too much business. The effort was quite successful, as was the entire meeting, for which the committee on arrangements deserves a bouquet of orchids. Incidentally, it should be mentioned that the Pacific sections of Exploration Geophysicists, and Economic Paleontologists and Mineralogists, held simultaneous meetings that were well attended and also productive of some very much worthwhile papers.

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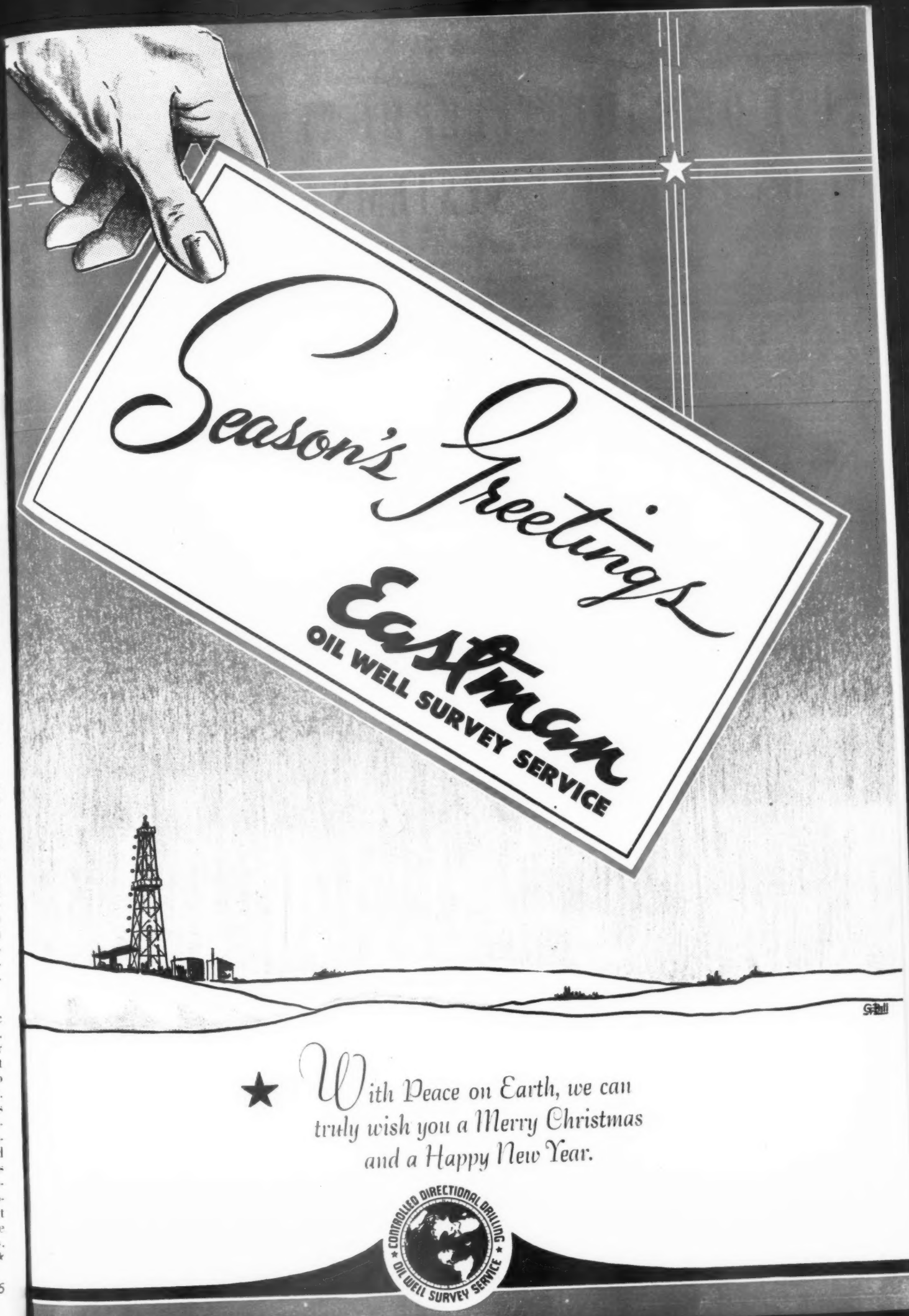
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USE OF RADIOTELEPHONE ON PIPE LINE SYSTEMS

TWO-WAY radiotelephone communication systems are coming into greater use in the operation of pipe lines, especially in areas where conditions are such that contact with company headquarters and field locations is difficult. Recently Union Sulphur Company of Sulphur, Louisiana, installed such a system* in connection with the operation of a 100-mile pipe line that it maintains for the Reconstruction Finance Corporation, Office of Defense Plants. The area is almost entirely swampy, and one location is inaccessible except over water.

The installation consists of one 250-watt transmitter-receiver at the main office, and a 250-ft. tower. Twelve portable 50-watt units and 5 mobile 50-watt sets are provided for cars and trucks. The system operates on 33,620 kilocycles.

The mobile units are operated by personnel who have supervision of maintenance, gas dispatching, communications, and drilling. As there are no regular telephones, the radiotelephone is the sole means of direct communication.

In some locations power is supplied by a public electric utility, in other places remote from power lines gasoline engine-driven generators provide the primary power.

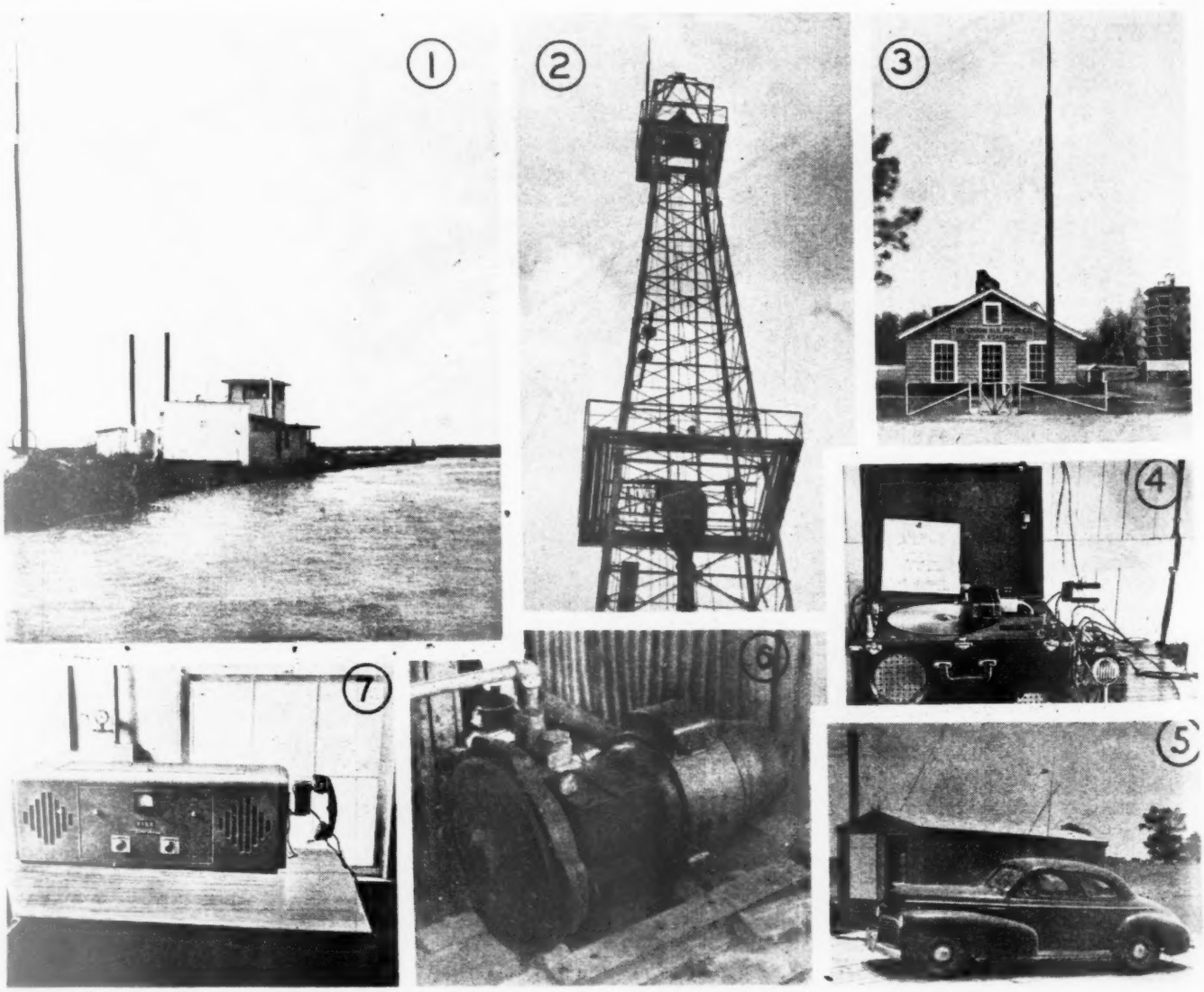
The Federal Communications Commission is allowing the company to keep station logs by means of an automatic recorder device, which is placed at the main pipe line station. This is believed to be the first time that a recorded log has been maintained on this type system. Its use eliminates troublesome filling out of forms, records, etc.

A similar radiotelephone system has been installed by the Union Gas Systems of Independence, Kansas, for use of personnel charged with keeping constant vigilance for failure and breakdown in operation of its pipe line. In this instance, also, a 250-watt transmitter-receiver has been installed at headquarters. Fourteen 30-watt mobile units have been installed in maintenance cars and trucks and 20 more units are being planned. A 250-ft. tower supports the main station antenna.

An unusual feature is that the main station is controlled from four different consoles, connected in parallel, at one time. One console is placed at the telephone switchboard, for immediate use by the maintenance and operating crews. Another is in the office of the president of the company, for close contact by top management with field per-

*Equipment by Galvin Manufacturing Corporation.

FIGS. 1-7. Principal features of Union Sulphur Company radiotelephone installation. Descriptions are in text of article.



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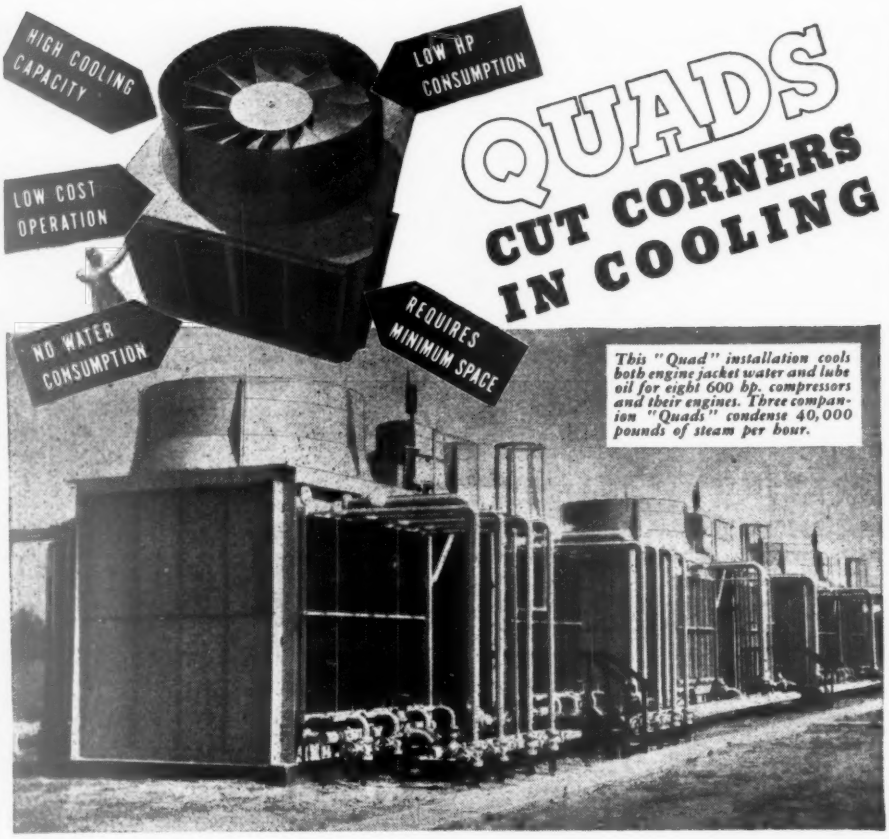
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sonnel throughout the system. The other two remote positions are at the base of the tower for checking and monitoring work, and in the gas measurement department where the superintendent in charge must keep in constant contact in event of emergency.

The accompanying photographs were taken on the system of the Union Sulphur Company and illustrate the principal features of that installation.

Fig. 1 shows the approach to the Lakeside field, which can be reached only by water. The antenna is attached to the pole in the foreground. The coaxial lead-in cable has not yet been connected to the set and is coiled at the base of the pole.

In the South Roanoke field the antenna is attached to a drilling rig. (Fig. 2). This is quite an unusual practice and shows the versatility of the installation. A coaxial cable leads from the antenna to the two-way radiotelephone unit.

Fig. 3 is an exterior view of a pumping station on the Union Sulphur pipe line system. The antenna is on top of the high pole in front of the station building, affording good reception and transmission. The two-way radiotelephone unit is inside the building and is remotely operated by a telephone handset.

Logs and records required by the Federal Communications Commission are being kept by an automatic recording device, as mentioned. (Fig. 4). This equipment makes a record of everything that is transmitted over the entire network regardless of which station does the transmitting. The label in the center of the record is then suitably inscribed with pertinent data, such as the date and the persons doing the transmitting, and the record is preserved the same as written logs have been in the past. This makes it unnecessary for the operating personnel to keep a written record each time the transmitters are used and thus speeds up operation of the entire system. The recording device is kept at the main station of the Union Sulphur Company.

Fig. 5 shows a field foreman's car with antenna attached to the top. It is hinged with a spring at the base to permit its passing under obstructions without breaking off the antenna. In this picture the car is parked outside the bunk house in the South Roanoke field. The car has a two-way radiotelephone installed in it and the occupant is able to contact headquarters from any point throughout the system.

A typical primary power plant is shown in Fig. 6. A steam turbine supplies rotary power to the dynamotor, which in turn provides electricity to run lights and equipment as well as the two-way radiotelephone equipment.

The two-way radiotelephone unit and console, which is situated inside the pumping station, is shown in Fig. 7. Connection to the antenna is through a coaxial cable of copper, which is kept filled with a dehydrating gas under pressure. The cable and its terminal gage can be seen in the background.

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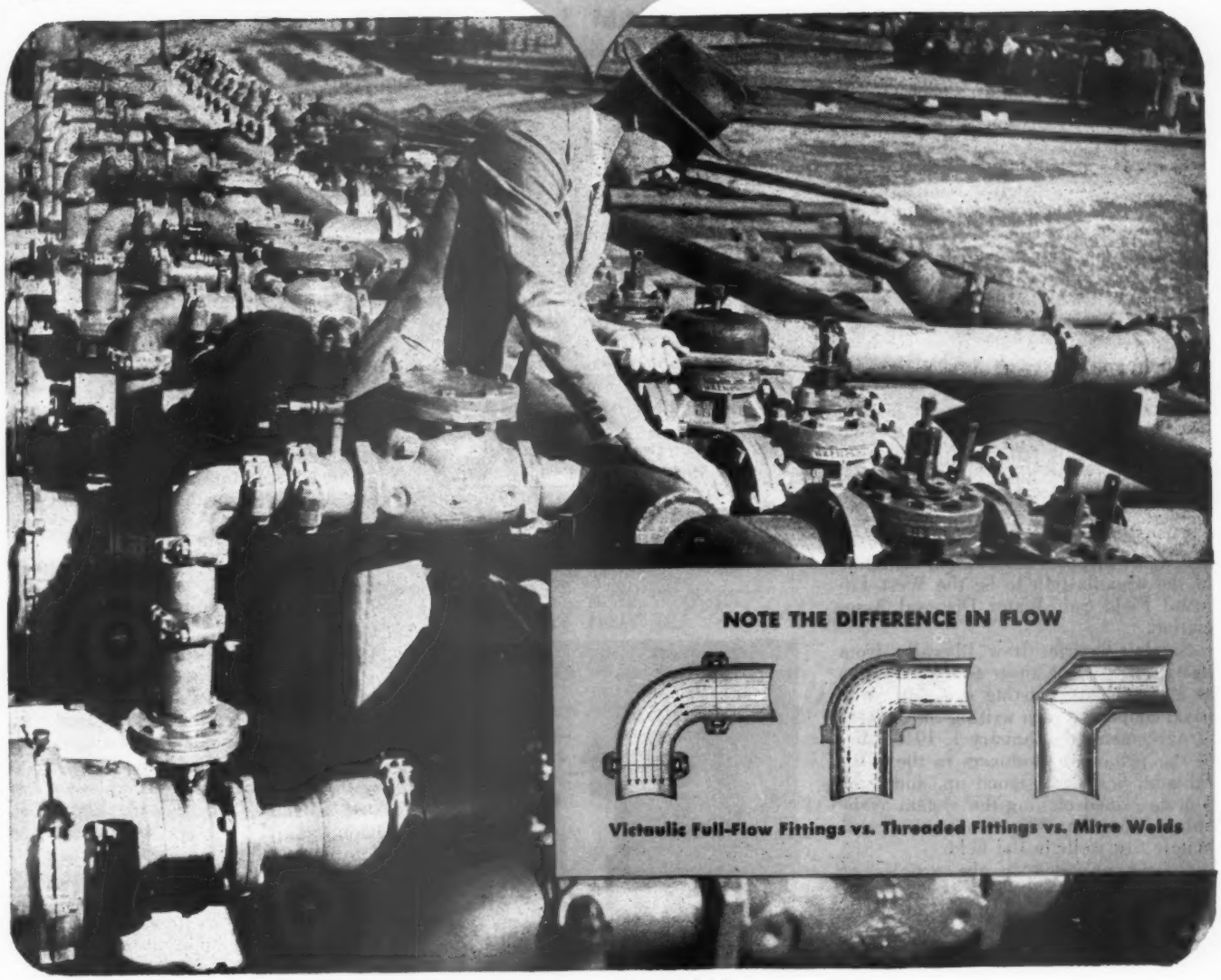

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WEST EDMOND SALT WATER DISPOSAL PLANT INITIATES SERVICE TO MEMBER OPERATORS

By **WILLIAM J. DAVIS**

EXCLUSIVE

FACED with the problem of encroaching salt water on the west edge of the West Edmond field, Canadian and Oklahoma counties, Oklahoma, and the existing statutes of the state making it compulsory to provide adequately for salt water disposal, operators of wells in the area have been working on the problem since early 1944.

A workable solution was suggested by Sinclair-Prairie Oil Company's production department, which proposed that the companies involved form a cooperative non-profit organization to build and operate a system for the collection and disposal by injection in a suitable sand accumulated salt water of the member operators. The proposal met with the approval of a large number of producers in the field and articles of agreement were drawn up for the formation of a salt water disposal association, the name of the organization to be the West Edmond Field Salt Water Disposal Association.

Sinclair-Prairie drew liberally from its experience in Kansas and other states as a member of existing salt water disposal cooperatives in writing the articles of agreement. By January 1, 1945, nine of the principal producers in the West Edmond field had signed up, and later 4 more joined making the system available to more than 80 per cent of approximately 616 wells in the field.

It was provided in the articles of agreement that any operator not in the original agreement could join the association by making proper application and assuming a prorated share of the cost of construction and operating expense.

Each producer that became a member was given one vote in the organization, regardless of the number of well operated, and the prorated share of expense to each producer was in proportion to the ratio of the number of producing wells owned by each member within the system to the total number of producing wells on all leases owned by members within the system. It was further provided that at the first meeting of members an "Operator" would be elected whose duty would be to construct and operate the system of the association, subject to the approval of members.

Such a meeting was called early in 1945 and Sinclair-Prarie was chosen as the operator.

With this definite plan of action agreed upon, application was filed with the Oklahoma Corporation Commission to inject salt water into the Hunton sand. Upon further consideration by the members of the association it was decided to inject into the Pennsylvania sand and an additional application was filed with the commission to that effect. By June 16, 1945, the commission had approved the plan and Sinclair-Prairie production engineers, acting in the capacity of operator, proceeded with plans to design and construct the system.

The best accepted practices of municipal water works and oil-field pipe line design were combined in the general design for handling salt water. All gathering lines were to be of corrosion-resisting cement-asbestos pipe having a working pressure of 50 lb. It was specified that sleeve-type couplings also were to be of cement-asbestos. Mains close to the collection station were designed of sufficient capacity to take care of all future anticipated extensions in the field.

Gathering laterals and mains were designed to handle a maximum of 500 bbl. a day from each connection in the system, which was the legal limit to which the association obligated itself in the articles of agreement. This figure was chosen as being well above any actual volume likely to be handled in profitable operation of wells within the field. The gathering system was to be a closed low-pressure system with booster pumps situated at points of low hydrostatic head.

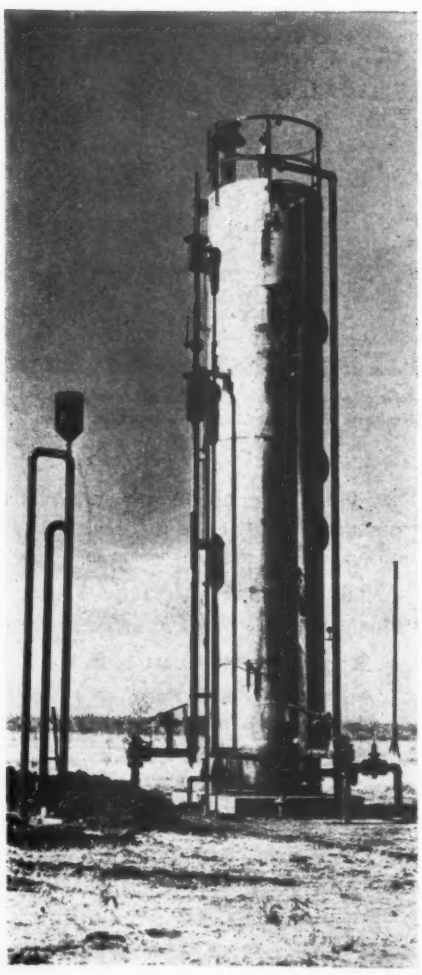
Estimated cost of building the system for eventually handling salt water from approximately 616 wells in the field was $1,381,433. Of this amount Sinclair-Prairie authorized the expenditure of $194,284 to initiate the work.

Rights-of-way were acquired by the association and survey of the gathering lines begun. Heavy rains in June and July delayed the work for weeks during which time final design and plans of the system were brought to completion.

In placing orders with equipment manufacturers, delays in delivery of equipment were posted at 4 months. Large items such as pipe, pumps, and electrical equipment had not had time to get into full-scale production.

Actual construction work was begun September 4, 1945, on laying gathering lines with the first delivery of cement-asbestos pipe. At this writing the first extension of 14 miles of gathering lines is nearing completion with salt water being taken at the collection station on Deer Creek. Temporary pumps have been set at the disposal well to inject the accumulated salt water.

As each lease in the area uses pressure-type heat treaters to knock out the salt water, some means had to be provided to protect the 50-lb. working pressure pipe in the gathering system from sudden surges of pressure. Such surges would occur when the dump valve of the treater suddenly released salt water into the line. Further protection to the system was needed when the disposal plant was not taking water and the dump valve acted. A three-pipe water leg has been designed by the production engineers to overcome this situation. The leg is made of 4-in. welded pipe and is connected directly to the dump valve connection. In



The vertical assembly to the left of the heat treater is to relieve sudden surges of pressure on the cement-asbestos pipe gathering system when the dump valve opens to admit salt water to the system. Should the disposal plant shut down for any reason, the salt water automatically goes to the waste pit.

Peace and rest at length have come

All the day's long toil is past

And each heart is whispering "Home,

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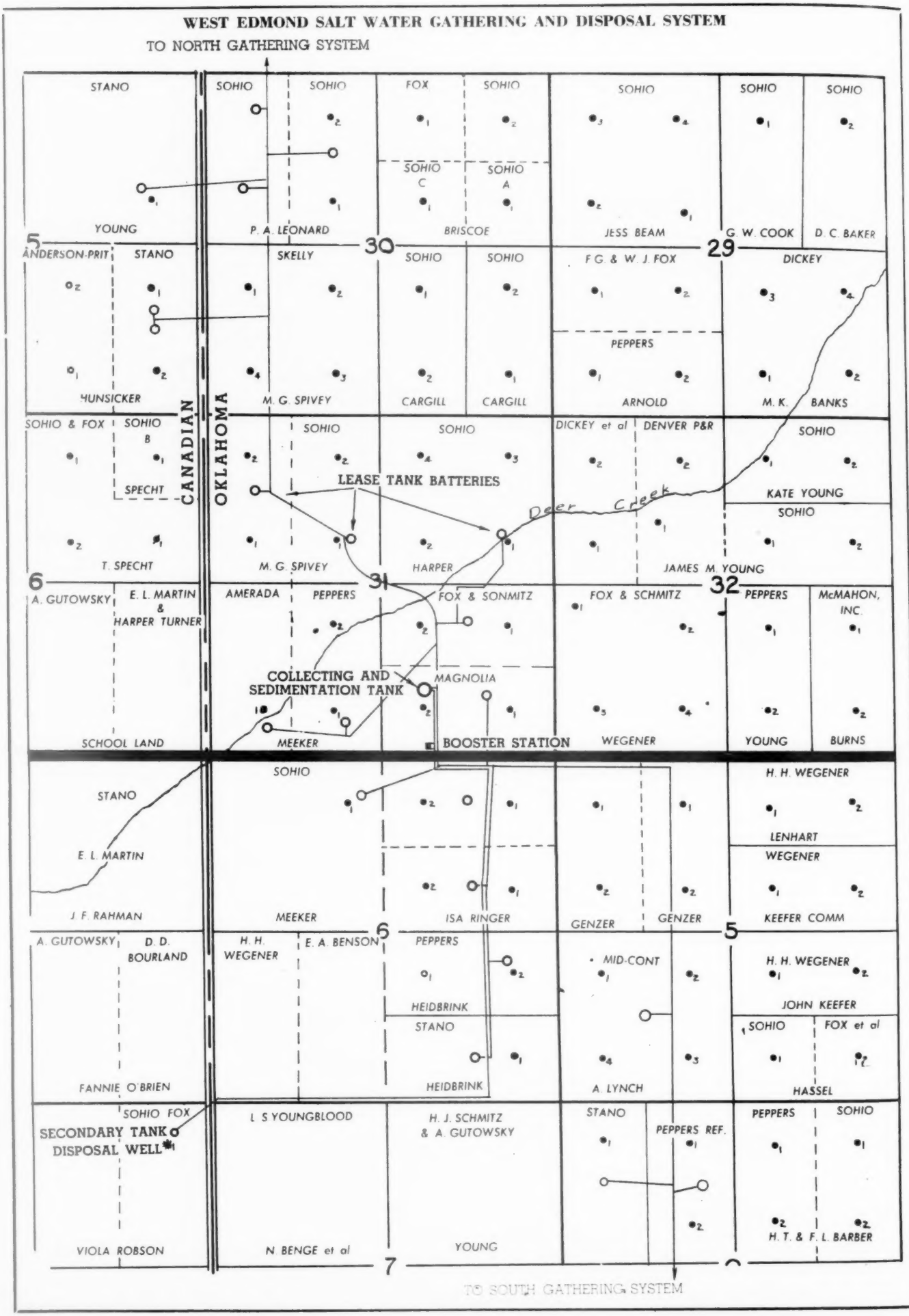
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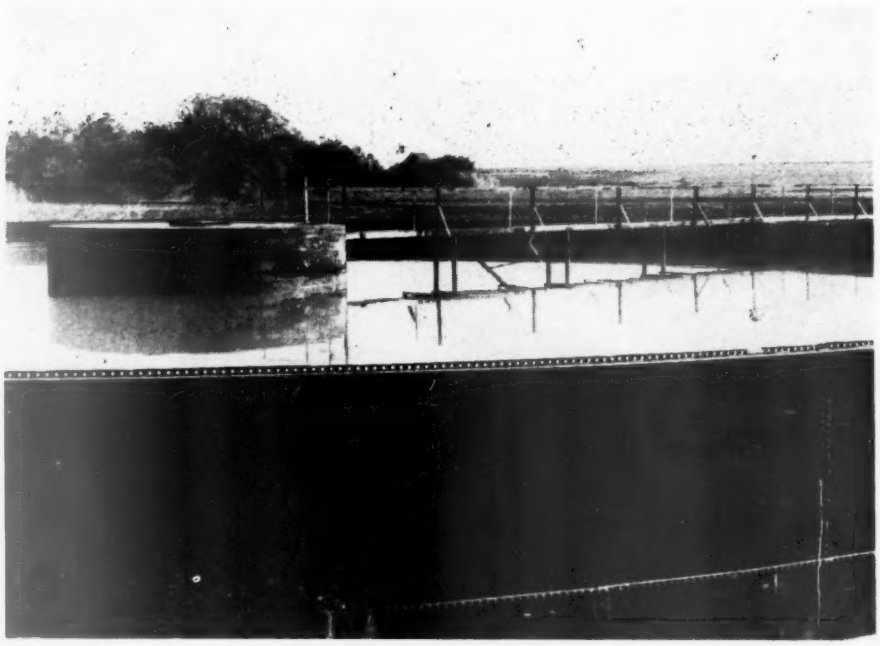


Sedimentation tank, 40,000 bbl. per day capacity, with catwalk to center well. Flow is radial from the tank circumference to the center well.

operation, salt water from the treater travels upward to the first pipe bend and downward through the middle leg to the gathering system line. Should the system be shut down for any reason and the dump valve open, the salt water would travel farther up the first leg, through the second pipe bend, then downward through the outside leg and be allowed to flow to the waste pit. A surge chamber has been installed at the top of the leg to increase the protection against sudden pressure rises.

Great care had to be taken in laying the cement-asbestos pipe as very little movement or deflection is allowed by the sleeve-type couplings. Precast bends and turns were used where sudden changes in elevation occurred.

Sizes of pipe in the gathering system included 3-in., 4-in., 5-in., 6-in., 8-in., 10-in., 12-in., and 14-in. Though the sleeve-type coupling was used for most of the system, a special coupling with bronze bolts has been developed by Sinclair-Prairie engineers to be used where opening of the line is anticipated.

This special coupling was made in Sinclair-Prairie machine shops by turning down over-size cement-asbestos pipe to slip over nominal-size pipe. Rings and gasket grooves were machined and holes drilled for from 4 to 6 bronze ⅜-in. bolts. All gaskets are of neoprene-type corrosion-resisting material. The coupling allows a limited deflection while still holding a tight joint.

The main collecting or sedimentation tank was designed from accepted practice and experience of settling basins used in connection with filtration of domestic water in municipal plants, the following conclusions having been generally accepted as proper limitations affecting the design of settling basins in general:

(1) That a particle 0.01 mm. in diam. is the smallest particle that can be economically removed without the addition of a coagulant.

(2) That the falling rate of such a particle in still water is 0.0005 ft. per sec.

(3) That a continuous flow settling basin properly baffled, is as effective in removing suspended matter as a series of intermittent settling basins.

(4) Effective settling may be accomplished when the mean velocity through the basin does not exceed 3 times the falling velocity of the particle to be removed.

(5) That the incoming and outgoing velocity of the fluid flowing through the basin can be as high as 25 times the mean permissible velocity.

(6) That the detention time in a rectangular basin must be 3 times longer than in a circular basin in which radial flow is maintained, to allow for end currents.

(7) That the working level of the fluid in a settling basin should not be less than 5 ft. in order to insure quiet fluid, or more than 15 ft. in depth, to insure maximum economical operation.

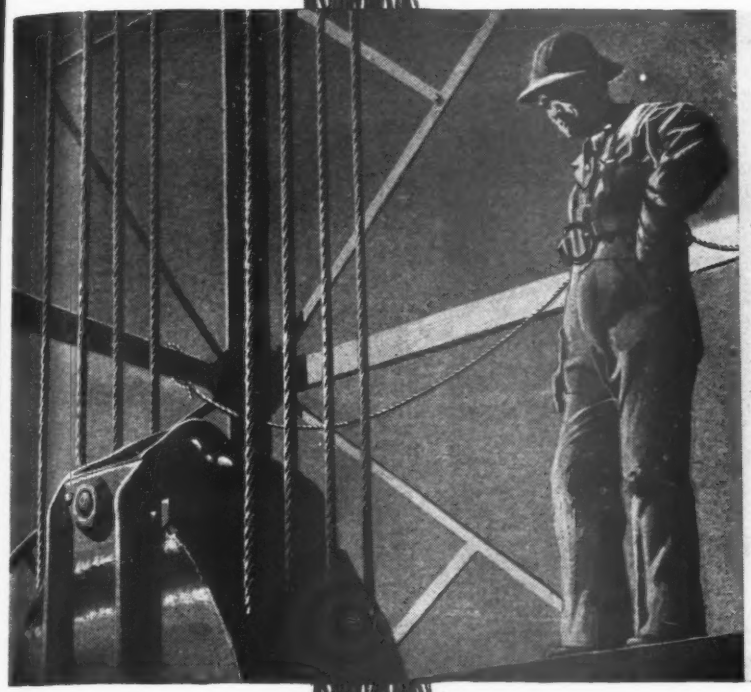
In the design of the sedimentation tank at Edmond the area of the slots in the transite spreader and the area of the center well were made of sufficient size to conform with the above accepted conclusions, to maintain the proper incoming and outgoing velocity, and attain the required velocity at the mean point of the settling basin, for a throughput of 40,000 bbl. a day.

Two rings of a 95-ft. diam. steel tank were used to construct the sedimentation tank. This gave a total wall height of 9 ft. 6 in. Around the inside circumference, 13-ft. sections of 10-in. cement-asbestos pipe with a horizontal slot 4 in. wide introduce salt water to the tank. These sections are connected by means of special couplings to form a continuous circle. Each coupling will allow a deflection of about 16 deg.

To regulate the flow, the couplings are loosened two at a time and the 10-in. pipe in each section rotated until the flow from the slot equals that of each of the other sections in the ring. This arrangement also allows for adjustment

Welding nipple on injection well to hold pressure gage.

Special cement-asbestos coupling with six bronze bolts and nuts as shown by W. E. Wines, production engineer for Sinclair-Prairie.



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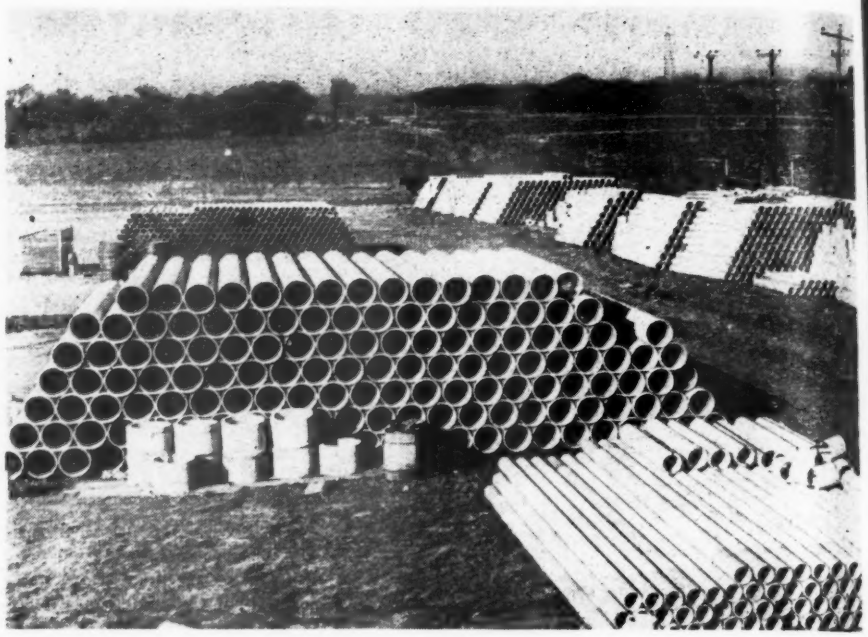

Pipe yard with cement-asbestos pipe ranging in size from 3 in. to 14 in. This pipe will be used for future extensions to the gathering system.

should the tank settle on its foundation and disturb the equilibrium of the system. An adjustment of plus or minus 5 in. can be accomplished.

The center well is of steel construction, 10 ft. 9 in. in diam., and rises 4 ft. from the floor of the tank. It is covered with a circular steel baffle resembling an inverted cup. The purpose of the baffle is to hold back the 2-in. film of oil on the surface of the salt water from the lip of the center well. The film of oil is used as a cover for the tank, excluding light and air.

Tank connections consist of a 10-in. inlet for the north and south gathering systems and a 10-in. outlet to the booster pump situated 976 ft. from the sedimentation tank.

Advantage was taken of a slight rise of ground approximately 1000 ft. from the location of the tank to place the booster pump out of the high water level of Deer Creek. The pump was set in a steel well 10-ft. square and 12-ft. deep to keep the suction low with respect to the hydrostatic head in the sedimentation tank. The steel pump well was anchored with ¾-in. turnbuckles and cable set in concrete to keep it from floating should high water or a leak around the outside piping tend to float it.

An all-bronze single-stage centrifugal pump with 2½-in. suction and 2-in. discharge picks up salt water from the sedimentation tank and delivers it a distance of 2 miles through 6-in. 100-lb. working pressure cement-asbestos pipe to the injection well surge tank. The pump is driven by a 7½-hp. electric motor and will deliver 8000 bbl. a day.

A modern application of electronics is used to control the starting and stopping of the booster pump. Outside the pump well, a 10-ft. diam. by 10-ft. long welded steel tank has been placed in the suction line to the booster pump. Two probes were inserted into the end of the tank on a vertical line and 12 in. apart. As the tank fills and salt water finally reaches the top probe, the pump will start and continue to operate until the lower probe has been uncovered by the water level. The action is automatic and needs no resetting.

It is asserted that the electronic tube used to detect and magnify minute currents in this relay is so sensitive that it

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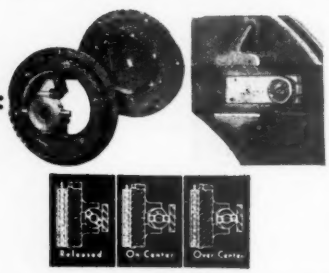

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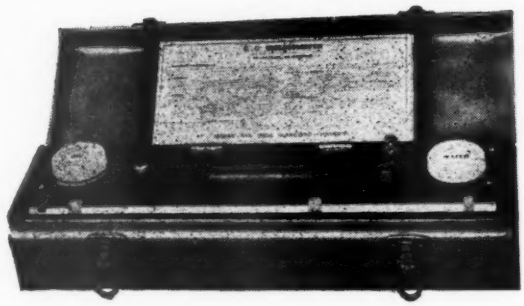
SEND FOR THIS HANDY BULLETIN ON POWER TRANSMISSION
It shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications. Every production engineer will find help in this handy bulletin, when planning postwar products.

ROCKFORD CLUTCH [FORMERLY KNOWN AS] DRILLING MACHINE DIVISION BORG-WARNER CORPORATION
1303 Eighteenth Avenue, Rockford, Illinois, U. S. A.

ROCKFORD CLUTCHES



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E-C INCLINOMETER

Our rental customers receive the E-C Inclinometer in this compact carrying case. They are assured of the security and accessibility of the contents.

The E-C Inclinometer is made of K-Monel Metal, which is the highest possible grade material and lends itself to great accuracy in fabrication. The carrying case also is of K-Monel Metal sheets and N. P. brass.

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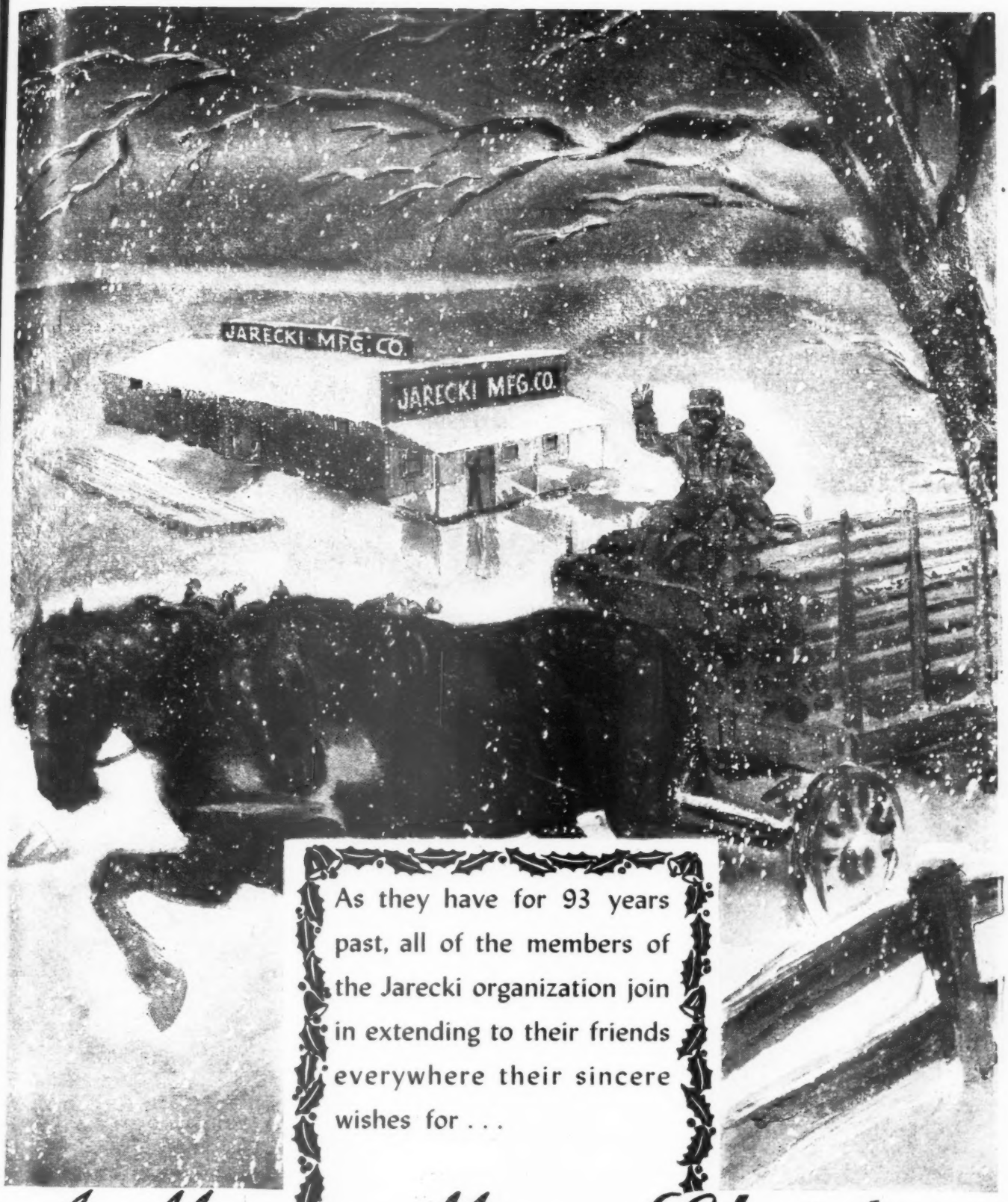
Offices: Philadelphia, Pa.; Houston, Corpus Christi, Marshall, Odessa, Texas; Lafayette, La.; Long Beach, Bakersfield, Calif.; Oklahoma City, Okla.; Casper, Wyo.



As they have for 93 years past, all of the members of the Jarecki organization join in extending to their friends everywhere their sincere wishes for . . .

A Merry, Merry Christmas

AND A NEW YEAR OF ACCOMPLISHMENT

JARECKI

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"Since 1852"

ACME DRILLING & FISHING TOOLS

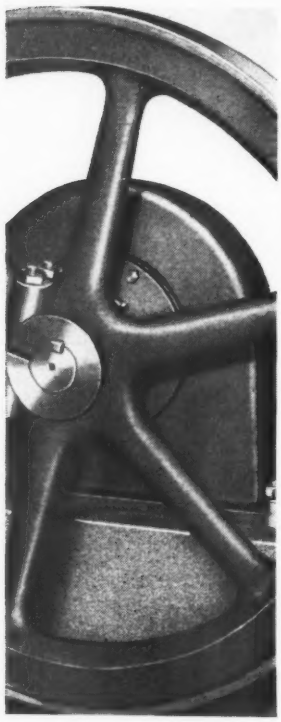
TWO "OLD RELIABLES" NOW ONE

PATTIN BROS. DIVISION of Acme Fishing Tool Co. Founded 1888 – Marietta, Ohio

The World's Standard of Quality in Oil Field Equipment - - -

Acme — Since 1900

Pattin — Since 1888



Speaking of

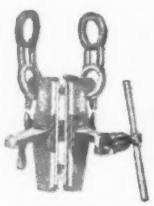
RUGGEDNESS - -

There are Pattin Units Still "Going Strong" After 40-Odd Years' Constant Service - - -

Recently we visited some Pattin "Old Timers" —Engines and Pumping Powers installed in 1903-4-5 and still serving well. And Compressors that have run 30 years, day and night. All are most convincing proof that Pattin's RUGGEDNESS, in comparative **slow** speed units, pays **extra** dividends, through ***life-long*** dependable performance.

The same stamina — plus more efficient and economical operation — that has made Pattin oil country equipment famous among two generations of owners is still the **safe** and **sane** foundation upon which our present day units, of improved design, are built.

With the present trend confirming our long experience, by favoring Pattin type lower speed, single cylinder, heavy duty engines, we shall continue building them — incorporating those qualities which assure more ***reliable*** power, LONGER, and lower service cost, all resulting in greater footage drilled or oil volume lifted per dollar invested.



Acme's 18" Safety Wire Line Clamp —

Fig. 103

Surest, safest, strongest for deep well drilling. Non-fouling safety links — tested to 208,500 lbs. breaking load. More gripping surface, permits loading up to 25 tons. Feature of both 18" and 12" Acme Clamps is slip retainers grooved to grip sand line . . .Use 12" size for drilling to 3000 ft. and 18" size for depths more than 3000 ft.

See Acme — Composite Catalog.

Typical Testimonials —

78-year old owner said: "My 42-year old Pattin Engine I've run every day."

Another said: "My Dad bought a Pattin 18 H.P. in 1904 which gives me excellent service." . . . Drilling contractor: "My Pattin 40 away out-pulls any I've ever seen." . . . Owner, 30-year old Pattin Compressor: "No mechanical defects yet and it runs continuously." Pattin pumping power owner: "I can practically 'forget it' between oilings."

PATTIN BROS. ENGINES POWERS — COMPRESSORS

"GLUTTONS for Life-Long Punishment"

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Export Office: 19 Rector St., New York 6, N. Y.

can be adjusted to close the circuit when a wetted hair is laid across the contacts.

A 15,000-bbl. 7/32-in. welded steel tank at the injection well assures adequate storage for the 3 injection pumps.

At present two oil-field type reciprocating pumps with two 125-hp. butane engines are being used to inject until delivery is made of electrical equipment for the planned installation.

The final installation will include three 5 by 10 duplex double-acting, side-pot type, all-bronze fluid end, reciprocating pumps. Pistons, valves, and seats will be of corrosion-resisting plastic. With 5-in. liners the pump can deliver 278 bbl. an hour at a pressure of 405 lb. per sq. in. and with 2½-in. liners 59 bbl. an hour at 1400 lb. per sq. in. Each pump is to be driven individually by a 100-hp. motor.

Here again an electronic level control starts one, two, or three pumps as needed to handle varying rates of accumulated salt water. In this installation, three probes have been inserted in the 15,000-bbl. tank in such a way that salt water covering the first one will start the No. 1 pump. An increase in the surge tank water level that causes the second probe to be covered, automatically starts the No. 2 pump. Should the rate of accumulation become even greater, which would result in the third probe being covered, the No. 3 pump is started.

As the rate decreases, the reverse is true, each pump being removed from the load as the level in the 15,000-bbl. tank uncovers the third, second, and first probe.

A simple change in the wiring can move the No. 1 pump to the No. 3 position for a rest and make the No. 3 pump the No. 1 for equalizing the work. This gives 6 possible combinations for the 3 injection pumps.

Double extra heavy 6-in. steel pipe connects the surge tank with the pumps and the pumps with the injection well. The heavy size was used to offset the effects of corrosion and the use of relatively high injection pressure.

The injection well is the Sohio-Fox No. 1 Robson, in the NE of the NE of Sec. 12, Township 13 N, Range 5 W, Canadian County. The well was originally drilled to a depth of 7430 ft. to the Sylvan Shale and in preparing it for injection purposes 4 perforations were made, the first at 4695 to 4715 ft., the second at 4840 to 4870 ft., the third at 4885 to 4920 ft., and the fourth at 4550 to 4600 ft.

Salt water is introduced through the 7-in. casing and testing of the well has shown that it will take approximately 8000 bbl. a day at an injection pressure of 750 lb. per sq. in. at the wellhead.

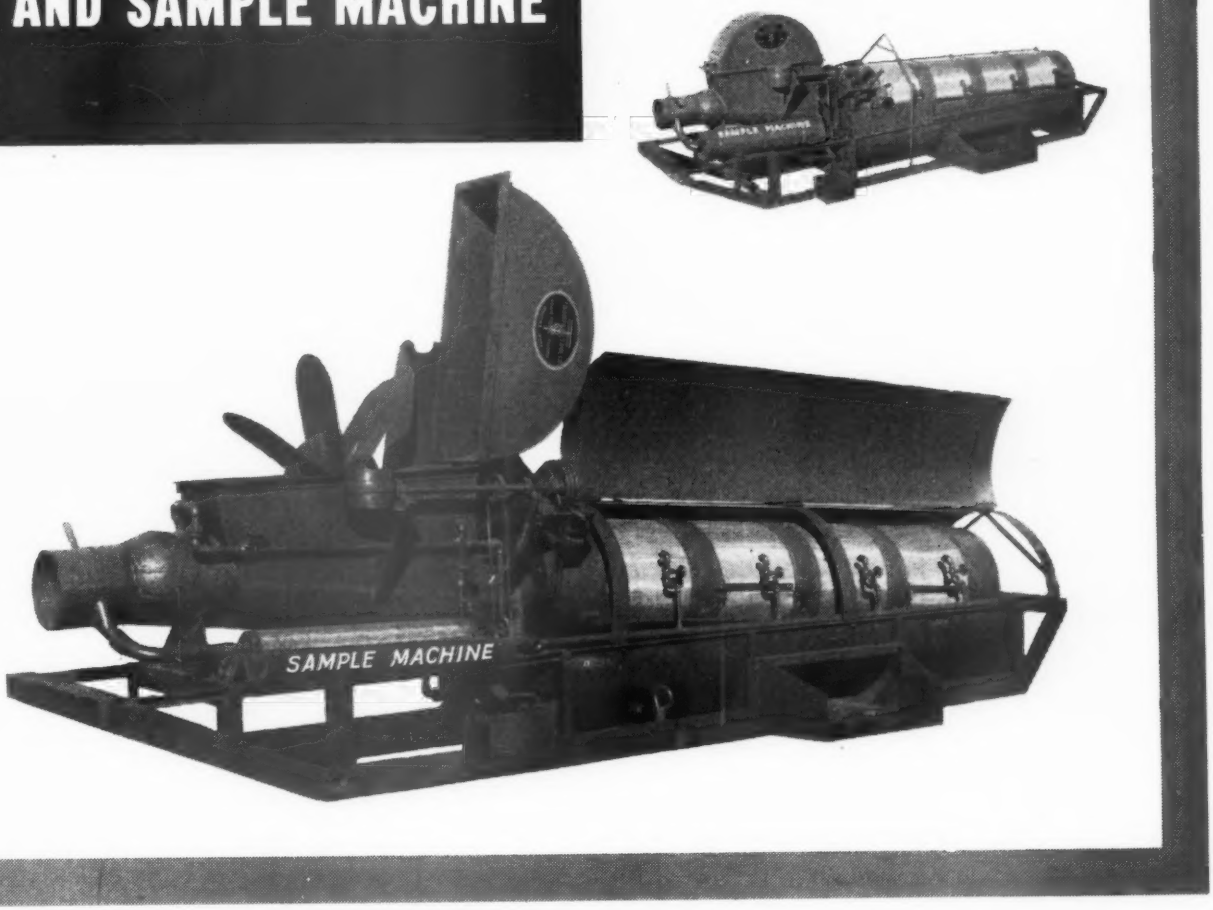
The necessity in the future of more injection wells will depend on the behavior of the present input well and the rate of increase of salt water encroachment in the field.

It is planned to expand the entire system as needed, adding more sedimentation tanks and pumps, as well as extending the gathering lines throughout the field.

★ ★ ★

IT PAYS FOR ITSELF IN SAVINGS IT EFFECTS

THE *Thompson* SHALE SEPARATOR AND SAMPLE MACHINE



By eliminating destructive abrasives from your drilling mud, the *Thompson* easily pays for itself with the savings it effects. Operates entirely from the flow of mud.

THE SAMPLE MACHINE, standard equipment on Thompson Shale Separators, provides accurate samples of foot by foot cuttings — a boon to geologists!

THOMPSON TOOL CO.
IOWA PARK, TEXAS

KEEPS DRILLING MUD *CLEAN* — PROVIDES *TRUE SAMPLES* OF CUTTINGS

PEACETIME UTILITY OF WARTIME PETROLEUM REFINING PROCESSES

By **F. D. PARKER,** *Development Engineer*

WITH the successful completion of the war against the Axis nations, the petroleum industry's major task changes from the production of war materials to the production of fuels, lubricants, and specialties required by industry and the consumer public. The following figures, taken from recent reports, indicate the size of the task performed by the refining branch of the industry and the magnitude of the reconversion problem in terms of capital equipment involved.

1. Prior to the war, the production of 100-octane gasoline in the United States was about 46,000 bbl. per day. In 4 years, this was increased to about 525,000 bbl. per day. This involved operation of a relatively small number of prewar units, plus construction and operation of many new units, the latter running about as follows (for the United Nations, with most of the plants in the U. S.):

Type plant	Approximate number of units
Alkylation	75
Catalytic cracking	77
Isomerization	37
Hydrogenation	4
Dehydrogenation	2
Miscellaneous	16

2. The petroleum industry and government spent approximately $1,000,000,000 on facilities related to the production of 100-octane aviation gasoline. Of this amount, about $850,000,000 was spent for facilities within the Continental United States, $620,000,000 of this being spent by private industry, a private investment percentage greater than that made by any other industry during the war.

3. Some of the facilities constructed in connection with the toluene program and the $800,000,000 synthetic rubber program (both largely government financed) have potential peace-time applicability.

The utility of the war-built plants in the manufacture of peace-time refined products is of interest not only to the refiners who installed one or more of these units for the production of aviation gasoline, but also to those refiners who, through consideration of individual economic, geographical, or transportation factors were not in a position to participate in the 100-octane program, or phases of the toluene and synthetic rubber programs, and now find themselves entering the postwar period with prewar refining facilities operating in competition with more modern facilities of other refiners. Although the problem of what plants can be operated economically is one that must ultimately be reviewed by each individual refiner in the light of conditions peculiar to his situation, there are certain more or less general technico-economic considerations that it is the purpose of this paper to review.

● **Predicted gasoline production and quality.** Considerable thought has been given by various analysts to the quantity and quality of postwar gasoline.

R. W. Reinhart[1] presents figures on past and predicted future gasoline consumption in the U. S. as follows:

Year	Million bbl. per year
1935	450
1936	475
1937	515
1938	525
1939	550
1940	590
.....	.....
.....	.....
1945	599
1946	640
1947	700
1948	745
1949	756

Burrill[2] is in general agreement with the above predicted postwar figures. Although disturbances in the war-peace transition undoubtedly will cause marked deviations from the 1945-46 figures, the predicted consumption for 1947-49 appears sound.

Risk[3] reports distribution of various quality gasolines for the prewar and predicts postwar distribution as follows:

Grade	Octane rating ASTM motor		Per cent of total gasoline	
	Prewar	Postwar	Prewar	Postwar
Aviation	91–100	100	2	6– 8
Premium	80	85–88	10	10–20
Regular	75	78–80	78	60–75
Third grade	64	68–70	10	5–15

There is a strong feeling in the aviation industry that a considerable portion of the aviation gasoline cited by Risk as averaging 100 octane will actually be of super-fuel quality such as alkylate-plus-isopentane-plus-lead. This will have a bearing on the economic operability of processes like alkylation and isomerization. Actual marketing trends show that regular grade and premium grade motor gasolines are, in many cases, already in the above predicted range.

Refinery capacity figures are reported[4] as follows:

Year	Crude oil charge capacity bbl. per day
1935	3,700,000
1936	3,850,000
1937	3,900,000
1938	3,900,000
1940	4,200,000
1941	4,500,000
1943	4,500,000
1944	4,700,000
1945	4,850,000

Referring to the above figures, it is evident that the petroleum refining industry is faced with the problem of producing motor gasolines 3-8 octane points above prewar values with yields of gasoline from crude oil equal to or exceeding prewar yields. From the point of view of number of installations (as listed above), the most important war-time processes available for solving this refining problem are alkylation, isomerization, and catalytic cracking. Catalytic polymerization and catalytic reforming (hydroforming) are prewar processes whose applicability to postwar operations is also of interest.

● **War-time processes available for peace-time operations.** As previously noted, the major private petroleum industry investment in new refining facilities during the war years was for high octane gasoline plants and related aux-

Process	Charge	Product	Approx. volume yield, per cent
Catalytic cracking	Narrow or wide-boiling virgin coke distillate, or visbreaker gas oil, or deasphalted resid.	Gasoline, 78-82 ASTM 88-95 research	40–65
Alkylation	Olefins: Propene, butenes, pentenes, polymer	Alkylate gasoline, 88-94 ASTM	160-170 on olefin
	Isoparaffin: Isobutane	88-96 research	
Polymerization	Propene, butenes	Polymer gasoline, 85-95 ASTM 95-105 research	65–75 on olefin
Butane isomerization	Normal butane, 92 ASTM	Isobutane (for alkylation)	100
Pentane isomerization	Normal pentane, 62 ASTM	Isopentane, 92 ASTM	96–100
Catalytic reforming (hydroforming)	Naphtha, 45-55 ASTM	Gasoline, 75-82 ASTM, 80-90 research	75–90

*Presented before California Natural Gasoline Association, Los Angeles, October 12, 1945.

iliaries. Papers describing the various catalytic cracking processes [5, 6, 7, 8], alkylation[9], butane and pentane-hexane isomerization[10] and hydroforming (including toluene purification)[11, 12] and integration of certain of these processes for high octane gasoline manufacture[13] have given adequate coverage of their respective subjects so that in this paper no attempt will be made to recapitulate previously published characteristic features of process, technology, operation, and refinery integration except as pertinent to the considerations at hand.

The significant items that are the concern of this paper are summarized in the table at the bottom of the preceding page.

Although the above processes are available to all refiners for postwar operation, the size of any installation will vary with the crude oil charge capacity, the nature of the crude processed, the products normally manufactured, and the details of existing process facilities and operations. As a matter of interest in determining the approximate size of individual modern refining units that might be operated for peace-time products, Continental U. S. refineries may be segregated into the crude oil charge capacity groupings as shown in the table on "Approximate distribution of U. S. refining capacity."

The above figures indicate that refineries in the 1,000-5,000 bbl. per day range predominate numerically, but have total charge capacity only above 8.0 per cent of the U. S. total. Refineries of more than 50,000 bbl. per day capacity represent 45 per cent of total U. S. crude capacity, but are few in number, and in most cases are owned by companies whose problems are handled individually and whose economic position, due to size, generally permits them to operate any or all of the processes installed by smaller refiners. The 5,000-50,000 range includes about 40 per cent of the refineries and 46.6 per cent of the crude oil charge capacity. Refineries in the 5,000-50,000 bbl. per day group will, therefore, as a group, be most concerned with the applicability of war-time refining processes to postwar operations, and the weighted average of their actions is most significant in setting product quality levels.

In considering catalytic cracking, alkylation, isomerization and the like in the light of peace-time conditions, it is convenient to estimate the approximate capacity ranges for each as related to refinery crude oil charge capacity. For purposes of this paper, 3 typical refinery capacities have been selected for illustrating the effect of plant capacity on economics. These refinery capacities are 5,000 bbl. per day, 15,000 bbl. per day, and 30,000 bbl per day corresponding to significant 5,000-50,000 bbl. per day range described above. In the following discussions it is understood that the 5,000 bbl. per day, 15,000 bbl. per day, and 30,000 bbl. per day figures refer to refining crude processed and are in addition to any other (and usually smaller) quantities processed primarily for products other than gasoline (such as lube oils, road oils and asphalts, diesel and other distillate fuels, solvents, waxes, etc.).

On the above basis, and by making use of generalized yields data characteristic of processing a typical 31-deg. API Los Angeles Basis crude oil[13] it is possible to set up figures that will approximately bracket the range of individual plant capacities corresponding to the 5,000 bbl. per day, 15,000 bbl. per day, and 30,000 bbl. per day refineries chosen for illustrative purposes. These are summarized as follows:

Approximate distribution of U. S. refining capacity[14]

Individual refinery crude oil charge capacity, bbl. per day	Approximate number of refineries	Per cent of total U. S. refineries	Approximate crude oil processed, bbl. per day	Crude oil, per cent of U. S. total
Less than 1,000	53	13.0	20,000	0.4
1,000- 5,000	162	41.0	400,000	8.0
5,000- 10,000	71	18.0	480,000	9.6
10,000- 25,000	59	15.1	850,000	17.0
25,000- 50,000	28	7.2	1,000,000	20.0
50,000-100,000	13	3.3	950,000	19.0
100,000 plus	10	2.5	1,300,000	26.0
	396	100.0	5,000,000	100.0

Approximate range of potential capacity of individual plants, bbl. per day.

Process	5000 bbl. per day refinery	15,000 bbl. per day refinery	30,000 bbl. per day refinery
Thermal or catalytic cracking	2000-4000 (3000 avg.)	6,000-12,000 (9000 avg.)	12,000-24,000 (18,000 avg.)
Alkylation (alkylate gasoline)			
Propene	200-300	600- 900	1200-1800
Butene	200-300	600- 900	1200-1800
Pentene	200-300	600- 900	1200-1800
Total	600-900	1800-2700	3600-5400
Propene-butene polymerisation	150- 250	450- 750	900-1500
Butane isomerization	100- 500	300-1500	600-3000
Pentane isomerization	50- 200	150- 600	300-1200
Catalytic reforming (hydroforming,)	1000-1500	3000-4500	6000-9000

The relatively wide range shown is explainable by the variety of refinery processing schemes and flexibility of operating conditions.

● **Approximate relative economics of peace-time operation of war-time processes.** The following discussion presents the results of some comparative studies of alkylation, isomerization, catalytic cracking, and other operations for motor gasoline production.

It is recognized that it is not possible to present firm figures applicable to every refiner's situation, since plant investment and operating cost, product yields and qualities, and charge stock and product values vary widely. By averaging typical data for each process and prorating direct and indirect charges, however, it is possible to set up curves showing value of product from each process as a function of plant capacity, and charge stock cost. Refinery overhead and management charges, and taxes and interest are not considered in this study, for they vary widely through the industry. With the understanding that the calculated figures are relative rather than absolute, it is then possible to draw some conclusions regarding utility of each war-time process in peace-time operations.

Following are the basic figures used or considered in these comparative studies:

Direct Costs

Labor
- Operating labor ..... $1.30 per man-hour
- Direct supervision ..... 25 per cent of operating labor

Maintenance .. 3-5 per cent of plant investment per year

Utilities
- Steam (high pressure) ..... $0.18 per 1000 lb.
- Steam (exhaust) ..... $0.08 per 1000 lb.
- Power ..... $0.005 per kw.
- Fuel ..... $0.13 per MM B.t.u.
- Cooling water ..... $0.005 per 1000 gal.
- Treated water ..... $0.05 per 1000 lb.

Chemicals ..... Market or manufacturers' prices

Royalties ..... Estimated licensors' "running" basis

Indirect costs

Depreciation ... 20 per cent of plant investment per year

Charge costs and products values
- Propane-propene ..... 2-6 cents per gal.
- Butane-butene ..... 2-6 cents per gal.
- Pentane-pentene ..... 2-6 cents per gal.
- Virgin gas oil ..... $1.25 per bbl.
- Catalytically cracked gas oil ..... 90 cents per bbl.
- Housebrand gasoline (79 ASTM octane) .6 cents per gal.
- Premium gasoline (86 ASTM octane) 7-7½ cents per gal.
- Tetraethyl lead (including leading cost) ... $0.002 per cc.

● **Alkylation.** Alkylation of olefin with isoparaffins to form high-octane gasoline components is not strictly a war-time process. The first commercial unit began operations in 1938, but by far the majority of the present 60 plants (sulphuric acid and HF acid processes) were constructed during the war. The alkylation process contributed significantly to the 100-octane aviation gasoline program with alkylate production reaching about 130,000 bbl. per day[15]. Applicability of the process to postwar motor gasoline operation is, of course, dependent on competitive economics.

Fig. 1 presents typical calculated alkylate gasoline costs as a function of alkylation plant capacity and raw material cost.

The following data, abstracted from Fig. 1, summarize costs for 2 "extreme" conditions:

(Continued on Page 122)

WORLD'S TOPS in topping capacity

Abadan, South Iran, site of this huge Anglo-Iranian Oil Company refinery, is in one of the world's most important producing areas.

In 1936 Badger designed and supplied a crude topping and vacuum unit rated at 71,000 bbls. per day of crude charge. So satisfactory was the performance that three more were purchased in 1937, 1939 and 1945, respectively. Thanks to the close co-operation with the refinery technicians which Badger engineers always strive to achieve, these units have all consistently operated at up to 86,000 bbls. per day crude input with closer cutting than ever. BADGER KEEPS ON TOP.

The aggregate crude run by these four units since commissioning exceeds—

HALF A BILLION BARRELS

Badger designing, constructing and erecting experience covers the entire range of distillation units—from largest to smallest. Badger knows how to modernize or replace older types of units toward obtaining more close-cut fractions—thus broadening the refiner's stocks for profitable specialized purposes.

LICENSING AGENTS FOR THE TCC PROCESS AND THE HOUDRY CATALYTIC CRACKING PROCESSES

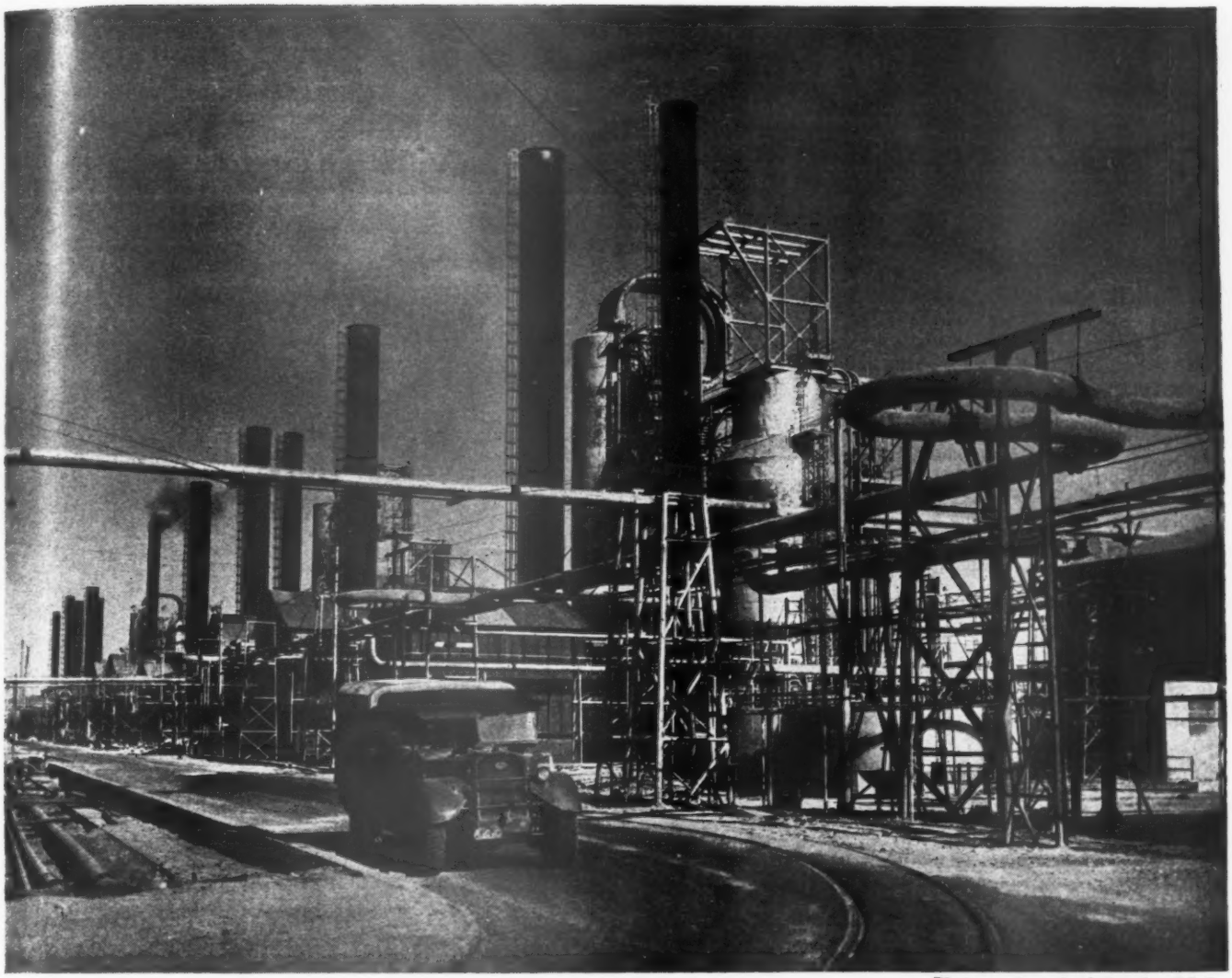


Photo courtesy Anglo-Iranian Oil Co.

The largest refinery in existence now operates four **Badger**-designed topping and vacuum units

E. B. Badger & SONS CO., Est. 1841

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PROCESS ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM, PETRO-CHEMICAL AND CHEMICAL INDUSTRIES

	Alkylate cost, cents per gal.	
	Small refiner (5000 bbl. per day± crude, 500 bbl. per day± alkylate)	Large refiner (30,000 bbl. per day± crude, 2500 bbl. per day± alkylate)
Direct cost	3.3	2.6
Direct cost plus depreciation (at 20 per cent)	4.9	3.8
Direct cost, plus depreciation, plus charge (at 2 cents per gal.)	7.4	6.3
Direct cost, plus depreciation, plus charge (at 4 cents per gal.)	9.9	8.8
Direct cost, plus depreciation, plus charge (at 6 cents per gal.)	12.4	11.3

With alkylate in average blends of 79 ASTM regular and 86 ASTM premium gasolines carrying a lead credit of 3-4 cc. per gal. (0.6-0.8 cent per gal.) and with refinery net-backs of 6 cents per gal. and 7 cents per gal., respectively for regular and premium gasolines, it is possible for even a relatively small refiner to produce alkylate economically for premium gasoline provided the charge stock to the process is worth 2 cents per gal. ($.84 per bbl.) or less. A large refiner could probably blend this alkylate to 6-cent regular gasoline. This would in general, limit the olefin charge stock to excess butenes beyond those that the refiner can use directly in motor gasoline as limited by vapor pressure specifications, and to propene. Similarly, isobutane from natural gas and gasoline and cracking operations (at about 2 cents per gal., where so available) rather than isobutane synthesized from normal butane is called for. As the operation is close to marginal, detailed study of each individual case is required.

● **Butane isomerization.** Isomerization of normal butane to isobutane is a process closely related to alkylation, for it provides a means of augmenting the supply of isobutane where this material is not available in sufficient quantity from natural gasoline or refinery stocks to meet alkylation requirements as determined by olefin availablity. The first commercial butane isomerization unit began operation in 1940; by far the major number of units were installed during the period 1941-45.

Fig. 2 presents calculated costs of isobutane as a function of plant capacity and normal butane charge cost. These figures are averages of typical isomerization plant costs and should not be construed as rigorous nor necessarily applicable to any particular process or installation. They indicate generally the economics of the process, however. For example, refiners contemplating the operation of alkylation plants for the pro-

	Isobutane cost, cents per gal.	
	Small refiner (5000 bbl. per day± crude, 300 bbl. per day± isomerization)	Large refiner (30,000 bbl. per day± crude, 1500 bbl. per day± isomerization)
Direct cost	1.0	3.3
Direct cost, plus depreciation (at 20 per cent)	2.0	0.6
Direct cost, plus depreciation, plus charge (at 2 cents per gal.)	4.0	2.6
Direct cost, plus depreciation, plus charge (at 4 cents per gal.)	6.0	4.6
Direct cost, plus depreciation, plus charge (at 6 cents per gal.)	8.0	6.6

FIG. 1. Typical alkylate gasoline costs as a function of plant capacity and charge cost.

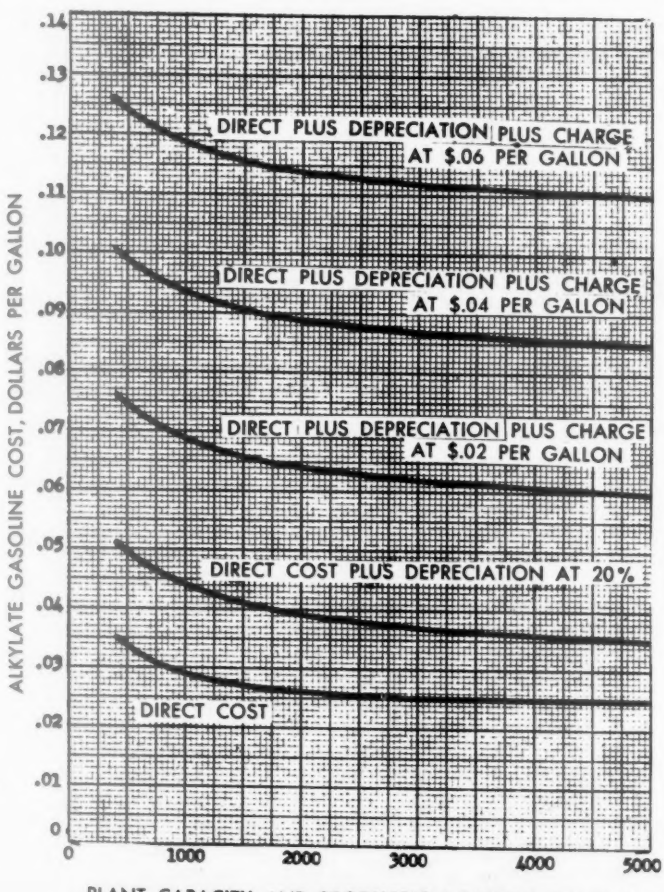
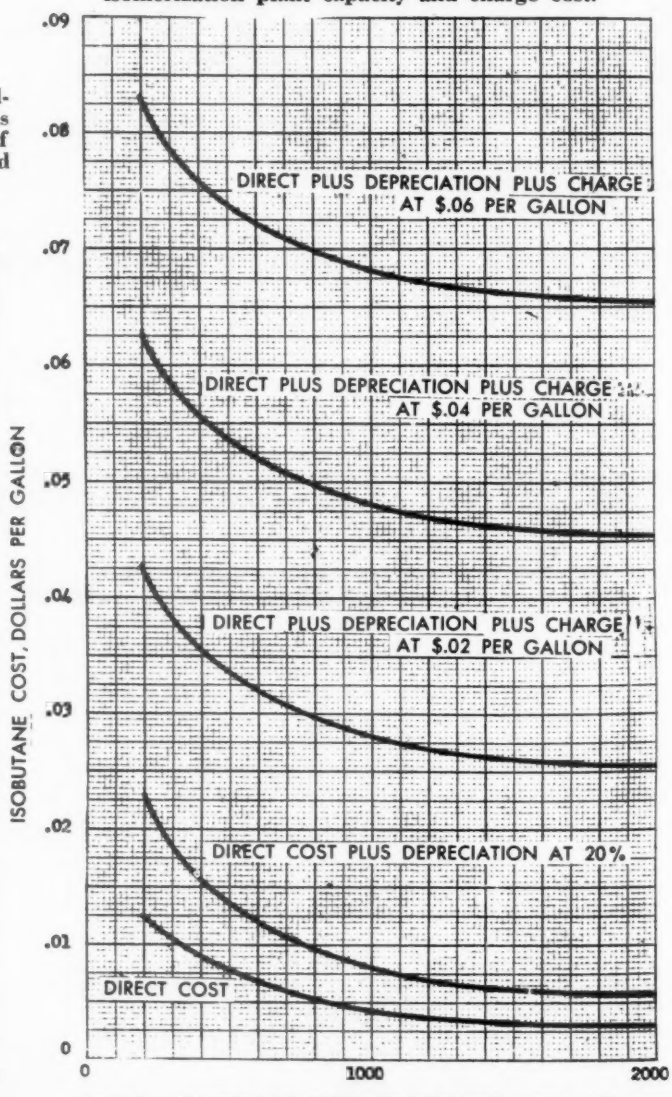


FIG. 2. Typical isobutane costs as a function of isomerization plant capacity and charge cost.



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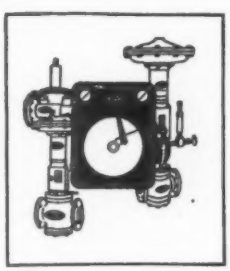

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duction of motor gasoline components, and faced with a shortage of isobutane, could produce isobutane from available normal butane in field and refinery stocks at the approximate cost in the table on page 122.

Referring to Fig. 1 for alkylate gasoline costs, it will be noted that each 1 cent per gal. increase in charge stock cost raises the alkylate product cost about 1.25 cents per gal. If alkylation plant olefin charge and normal butane are both available at 2 cents per gal., the isobutane produced by isomerization for reaction (with olefin to form alkylate) will cost 2.6-4 cents per gal. and the average charge to the alkylation plant will cost 2.3-3 cents per gal. (on the approximate basis of equal volumes of isobutane and olefin reacting). The alkylate gasoline will, therefore, cost 0.38-1.25 cents per gal. more than if 2-cent per gal. isobutane were available from field sources or cracking.

From the above it appears that butane isomerization is a marginal operation, and its applicability a function of isomerization and alkylation plant capacities, extent of amortization of each, cost of field or refinery butane as related to fuel gas and liquefied petroleum gas market prices, and outlet for alkylate (in aviation, premium, or regular grade motor gasoline) and hence value of alkylate.

● **Pentane isomerization.** Commercial isomerization of normal pentane to produce isopentane is truly a war-time process; the first unit beginning operation in 1944[16].

	Isopentane cost, cents per gal.	
	Small refiner (5000 bbl. per day± crude, 200 bbl. per day± isomerization)	Large refiner (30,000 bbl. per day± crude, 1000 bbl. per day± isomerization)
Direct cost (less small by-product credit)	1.6	0.75
Direct cost, plus depreciation (at 20 per cent)	2.6	1.15
Direct cost, plus depreciation, plus charge (at 2 cents per gal.)	4.6	3.15
Direct cost, plus depreciation, plus charge (at 4 cents per gal.)	6.6	5.15
Direct cost, plus depreciation, plus charge (at 6 cents per gal.)	8.6	7.15

Fig. 3 presents calculated economics for the process. As in the case of butane isomerization, there are a number of processes available, each with characteristic features and economics so that the cost information of Fig. 3 is necessarily a rough average only, and not necessarily applicable to any particular process or refinery situation.

Fig. 3 indicates refiners processing about 5,000 and 30,000 bbl. per day of crude oil respectively can produce isopentane at the following approximate costs:

With 79 ASTM housebrand gasoline at a refinery net-back of 6 cents per gal. and normal pentane charged to the process at a value of 5.7-5.9 cents per gal. (account lead penalty) a large refiner can consider pentane isomerization because isopentane can be produced at a

FIG. 3. Typical isopentane costs as a function of plant capacity and charge cost.

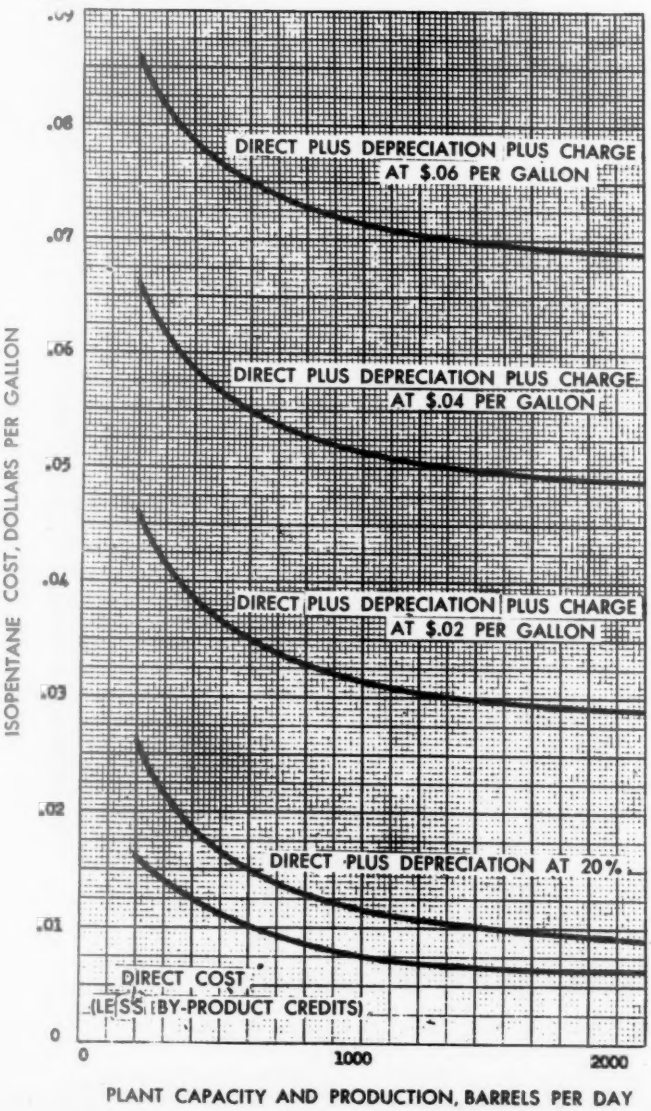
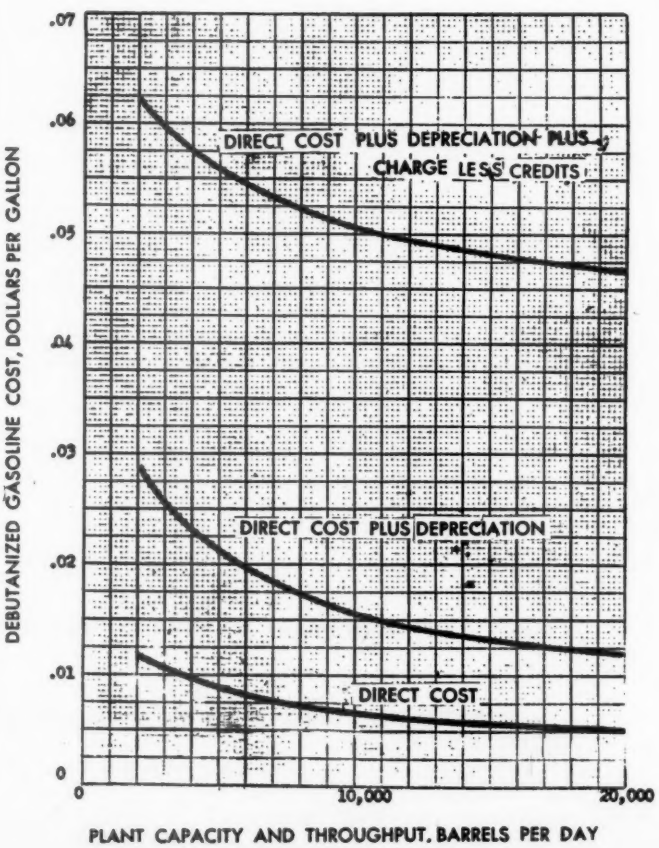


FIG. 4. Typical catalytically cracked gasoline costs as a function of plant capacity.

BASIS—RECYCLE CRACKING
GAS OIL CHARGE: CALIFORNIA WIDE-BOILING
GAS OIL AT $1.25 PER BARREL
BUTANE PRODUCT AT $.02 PER GALLON
DRY GAS (C_3 AND LIGHTER) AT $0.13 PER MILLION B.T.U. LHV
CATALYTIC FUEL OIL AT $.90 PER BARREL
PRODUCT RECOVERY INCLUDED



cost including depreciation of about 6.9 cents per gal., which is about the calculated refinery net-back for 6-cent regular grade gasoline plus lead credit for the high-octane of isopentane. In a typical premium blend the normal pentane is worth about 6.4-6.6 cents per gal., the resultant isopentane costs about 7.6 cents per gal., is worth about 7.9 cents per gal., and the economics are more favorable.

The above figures are altered when including a penalty for vapor pressure. For example, normal pentane and isopentane have vapor pressures of 15.5 lb. per sq. in. and 21 lb. per sq. in. respectively. Each volume of normal pentane can, therefore, carry about 0.15 volumes of normal butane and the mixture have a vapor pressure of 21 lb. per sq. in. The isopentane product therefore carries a penalty 0.3-0.6 cent per gal. (depending on butane value) for volume reduction in "gasoline-plus-butane" that can be made without exceeding vapor pressure specifications. On this basis, the isomerization process can be operated with about a 5-year write-off if plant capacity and production are of the order of 1200 bbl. per day, corresponding to a 20,000-30,000 bbl. per day refinery as defined in this paper. Detailed studies of each individual case of course must be made. The same general concepts apply to isomerization of heavier components such as hexanes and heptanes. Although commercial operation of the latter process has not been as extensive as have butane and pentane isomerization, it is possible that future developments will prove that these are economical methods for octane improvement.

It should be noted in this connection that at the present time all isomerization processes require relatively pure charge stocks and the cost of their preparation has not been included in the cost shown in Fig. 3. Thus, it is not possible for a refinery to charge a cracked C_5 fraction containing isopentane, normal pentane and pentenes. Normal pentane and isopentane can be charged together, but the C_5 fraction from cracking operations must be processed, as in an alkylation plant, to remove the olefins prior to isomerization. The economics of pentane isomerization are, therefore, closely related to the overall economics of the particular refiner, including his alkylation plant capacity and the cost of operation at various production rates.

Isomerization of pentane, hexane, and heptane as an adjunct to natural gasoline processing appears to warrant consideration provided sufficient charge stock is available at a central point. Thus, if normal pentane is present in natural gasoline to the extent of 15 per cent, and a 1000 bbl. per day pentane isomerization plant is considered as an economic minimum, the isomerization process would be applicable to a natural gasoline plant handling some 280,000 gal. per day of casinghead.

● **Catalytic cracking.** Catalytic cracking, of which about 1,000,000 bbl. per day potential charge capacity was installed during the war, represents the major industry investment and the prime factor is determining industry-wide average octane rating of motor gasolines because of the relatively high ratio of catalytic cracking capacity to crude oil distillation capacity. As is well known from published information on the various catalytic cracking processes, each has characteristic technological and operating features that show up in product yields and qualities, investment costs, and operating costs. Furthermore, economics of catalytic cracking are, of course, related not only to size of installation, but to type of charge stocks available, number and quality of products other than motor gasoline that it is desired to produce, availability of means (such as alkylation or polymerization) for utilizing light fractions (gas, propene-propane, butene-butane, etc.) refinery utility balances and costs, market demand and prices for gasoline, distillate, and residual products, and competitive gasoline quality level[17].

In a general paper of this type, it is not the intention to cover all the above points, but rather to illustrate the general economic applicability of catalytic cracking. Using typical data for recycle cracking California stock (50-60 per cent yield), the Fig. 4 has been prepared to show the calculated cost of catalytically cracked gasoline as a function of reactor fresh feed capacity and throughput. The following basis for charge and credits was used:

Gas oil charge, $1.25 per bbl.

Catalytic fuel oil, 0.90 per bbl.

Butanes, 0.84 per bbl. (2 cents per gal.).

Dry gas (C_3 and lighter), 0.13 per MM. B.t.u.'s.

The following approximate costs for debutanized catalytically cracked gasoline are summarized from Fig. 4.

	Gasoline cost, cents per gal.	
	Small refiner	Large refiner
Direct cost	1.1	0.6
Direct cost, plus depreciation (at 20 per cent)	2.5	1.3
Direct cost, plus depreciation, plus charge, less by-product credits	5.9	4.4

The catalytic cracking operation is shown by the above figures to be attractive, for even when using conservative charge cost and by-product credits, the 78-82-octane catalytic gasoline can be produced at a cost including depreciation below the 6-cent per-gal. net-back for 79-octane regular gasoline used in this study. Furthermore, the catalytic gasoline can be leaded to 86 ASTM premium grade (at a refinery net-back of 7 cents a gal.) with about 0.6-1.0 cc. tetraethyl lead per gal. (raising the gasoline cost only .12-.20 cent per gal.) as compared to the maximum of 75-79 octane that can be reached by heavy leading (2-3 cc. per gal.) of thermally cracked or reformed stocks.

In addition to the catalytic gasoline, catalytic cracking operations under recycle conditions usually produce C_3 and C_4 cuts rich in unsaturated hydrocarbons, and hence desirable as feed stock to polymerization or alkylation plants. Polymer gasoline (95 ASTM octane blending value) to the extent of 8-12 per cent of the debutanized catalytic gasoline is recoverable by polymerization of C_3 and C_4 unsaturates. As an alternative, alkylation of these olefins can be practiced with considerations discussed in the section on "Alkylation" applying.

● **Catalytic polymerization.** Although not in a category of a war-time process, a number of catalytic polymerization plants were converted to production of certain essential products during the war period, such as selective polymer and codimer (for ultimate hydrogenation and inclusion in aviation gasoline as hydrocodimer) and cumene. With the coming of peace, most of the 100 or more catalytic polymerization plants are reverting to their prewar operation of nonselective polymerization of C_3 and C_4 olefins for motor gasoline production.

Since, as noted above, catalytic polymerization fits in well with most catalytic cracking operations, a tabulation of typical calculated costs of butane-free polymer gasoline are presented at the bottom of the page.

These costs include cost of H_2S removal from the charge stock. The charge cost is, of course, variable, depending upon particular refinery stock balances and product market prices.

With tetraethyl lead credit for octane, (0.8-1.0 cent per gal. in typical blends) and with credit for additional butane that can be carried in the gasoline along with the polymer gasoline, polymerization can be considered an economical process, even for the small refiner, with 2 cents per gal. charge stock. With 3 cents per gal. charge stock, the polymer costs about 8 cents per gal. and the process becomes marginal in comparison with direct sale of the charge as, say, liquefied petroleum gas. Processes such as polyforming and gas reversion are also available for converting these fractions to motor gasoline by thermal means, usually in conjunction with naphtha reforming.

● **Catalytic reforming (hydroforming).** Prior to the war, there were 3 hydroformer installations, and during the war 5 additional plants were placed in operation, primarily for the production of toluene. Because of the relatively

Typical calculated costs of butane-free polymer gasoline.

	Polymer cost, cents per gal.,	
	5000 bbl. per day± refiner	30,000 bbl. per day± refiner
Direct cost	2.1	1.0
Direct cost, plus depreciation	3.6	1.8
Direct cost, plus depreciation, plus charge (at 2 cents per gal.)	6.5	4.7
Direct cost, plus depreciation, plus charge (at 4 cents per gal.)	9.4	7.6

small number of plants, each more or less of special design, it is difficult to make generalized economic statements regarding the process. The following figures, however, are believed representative for a 5000-bbl.-per-day plant processing low-sulphur virgin naphtha:

Direct cost of hydroformed gasoline.....	1 cent per gal.
Direct cost, plus depreciation (at 20 per cent).....	1.6 cents per gal
Direct cost, plus depreciation, plus charge ($2.10 per bbl.), less by-product credits.	7.7 cents per gal

Considering 76 ASTM octane house-brand gasoline and 86 ASTM octane ethyl gasoline market prices as 6 cents per gal., and 7 cents per gal., respectively, indicates that the hydroforming process can be considered only as marginal with charge stock at 5 cents per gal. (account lead penalty). Certain conditions peculiar to an individual refiner such as low-value charge stock may alter this picture. As the economics of the 5000-bbl.-per-day installation are questionable, however, it is significant that at the present stage of process development, smaller units such as those associated with a 5000-bbl.-per-day refinery would in all probability be uneconomical. The basic concept of selectively altering the molecular structure of compounds present in gasoline with high yield is sound, and technological and economic advances can be expected.

● **Summary.** As an indication of the relative utility of the various war-time refining processes in peace-time operation, the following figures, drawn from the above discussion, are pertinent:

1. Assuming prewar operations involved the production of gasoline from the 31-deg. API Los Angeles Basin refining crude by distillation, reforming, and cracking, this gasoline might represent about 40 per cent of the crude and consist of the following:

	Vol. per cent
Light straight run	22.4
Reformate	26.2
Cracked gasoline	46.6
Butanes	5.8
	100.0

The above blend has a calculated clear ASTM of 71, and a lead susceptibility such that 79 octane is reached with 1.3 cc. TEL per gal.

2. Alkylation of all C_3 and C_4 olefins from reforming and cracking might increase the volume of the gasoline 25 per cent (10 per cent on crude) and increase the clear ASTM octane of the blend about 3.8 points. The incremental gasoline would cost 6.5-7.5 cents per gal. with 2-cents per gal. charge stock.

3. Pentane isomerization would not increase the gasoline yield but would raise the clear ASTM octane of the blend about 2 points. The isopentane would cost 7-8.4 cents per gal.

4. Catalytic cracking replacing thermal cracking at no increase in gasoline yield (conservative basis) would increase clear ASTM octane of the gasoline blend about 5.5 points. Designing for maximum yield by catalytic cracking might increase gasoline yield from the refinery 25 per cent (10 per cent on crude) and the clear ASTM octane of the gasoline blend about 6.5 points. The catalytic gasoline would cost 4.4-5.9 cents a gal.

5. Polymerization of C_3 and C_4 olefins might increase gasoline yield 10 per cent (4 per cent on crude) and increase the clear ASTM octane of the blend about 2.5 points. The polymer gasoline would cost 4.7-6.5 cents per gal. with 2-cents-per-gal. charge stock.

6. Catalytic reforming (hydroforming) replacing thermal reforming might increase the gasoline yield about 5 per cent (2 per cent on crude) and raise the clear ASTM octane of the gasoline blend about 6 points. This gasoline would cost 7.7 cents per gal. or more.

● **Conclusions.** It should be again emphasized that it is impossible in a paper of this type to draw universally applicable conclusions, and that a process definitely uneconomical for one refiner may be economical for another because of financial, technological, or marketing features peculiar to him. The calculated costs presented in this paper are of necessity based on averaged factors for labor, maintenance, utilities, chemicals, and plant investment; plants designed specifically for individual applications may therefore show costs appreciably different from those presented herein. Furthermore, technological advances will certainly improve the economics of all processes that are, by nature, of utility and hence maintained in operation and in a continuous state of development.

Based on the process reviews of this paper, and bearing in mind the above qualifications, the following general conclusions can be drawn with regard to the peace-time utility of war-time refining processes:

1. The most generally applicable refining tool commercialized during the war is catalytic cracking.

(a) It produces high yields of high octane gasoline (unattainable by thermal reforming or cracking) from low-valued stocks.

(b) It produces relatively high yields of C_3 and C_4 unsaturates, which can be processed by alkylation or polymerization to supplement the yield of catalytic gasoline.

(c) Although gasoline quality measured by ASTM octane is high, of greater significance is the wide spread between ASTM and Research octane (the latter running 8-12 points above ASTM). This is generally indicative of superior road performance of the fuel, which is the true measure of fuel quality[18] and which is destined to become a prime factor in competitive sales.

(d) Investment and operating costs for small units are not disproportionately high per unit of charge or product.

(e) In certain cases, existing thermal cracking furnaces and towers can be utilized, to minimize investment.

2. Thermal or catalytic polymerization of C_3 and C_4 unsaturates otherwise disposed of to fuel gas or low-priced liquefied petroleum gas is, as before the war, an economical operation for virtually all refiners conducting cracking operations.

3. Alkylation of C_3 and C_4 unsaturates and isobutane to the extent that they are available in excess of specification vapor pressure gasoline (and hence disposed of to low-priced fuel gas) is economical for large refiners and marginal for small refiners. Alkylation of materials such as pentenes charged in at adjusted gasoline values does not appear justifiable for motor gasoline production but may be economical in large scale operations for production of aviation fuel.

4. Isomerization of normal butane to isobutane for subsequent use in alkylation is justifiable economically only if field or refinery isobutane costs 1-2 cents per gal. more than normal butane, and alkylate produced therefrom is incremental and hence of low unit cost.

5. Isomerization of normal pentane to isopentane for octane improvement is economical only where suitable normal pentane charge can be easily segregated (as from straight run gasoline) and in relatively large capacity units. This process, together with C_7 and C_8 isomerization, appears potentially applicable to large natural gasoline plants, especially if they are operated in conjunction with crude oil refining facilities. Isomerization processes may be of value in the production of special aviation super-fuels.

6. Hydroforming, in the present stage of development, does not appear economically justifiable for up-grading octane of naphtha for motor fuel, but may be suitable for certain specialized operations such as aromatic chemical production.

It is certain that the accelerated progress in refining technology made under the pressure of war will continue. Processes developed in the last few years will be further improved and the knowledge and experience gained will lead to new processes. These will benefit all mankind through more efficient utilization of our natural petroleum resources, and the manufacture of products used in industry and commerce, to the ultimate end of reestablishing and maintaining a world at peace.

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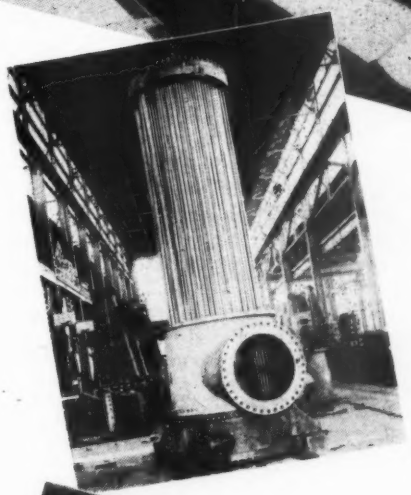

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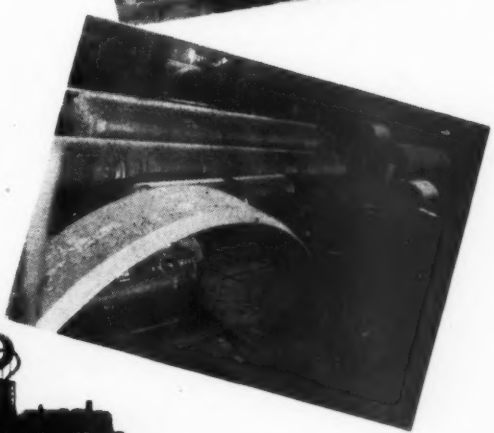

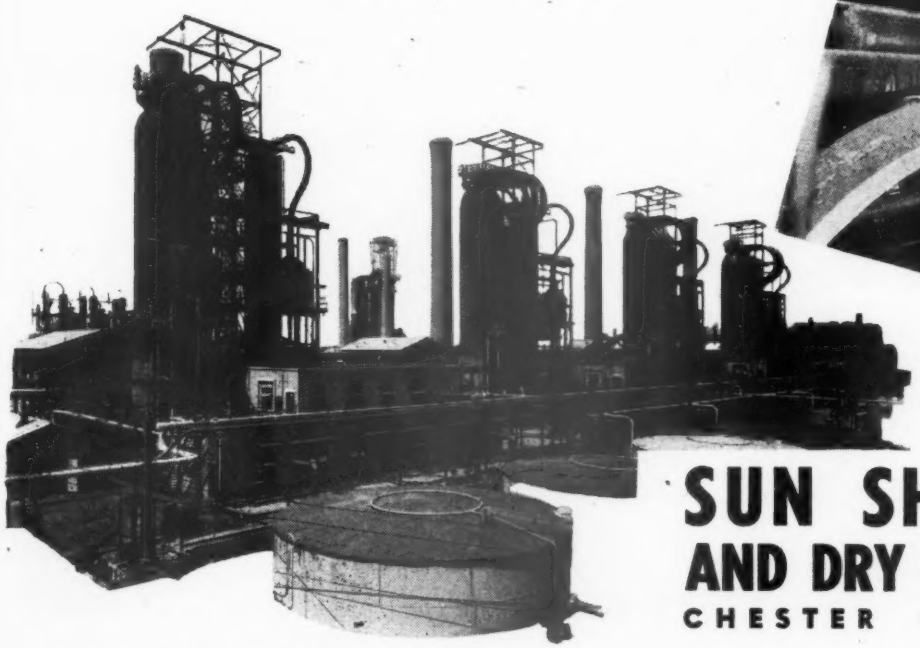

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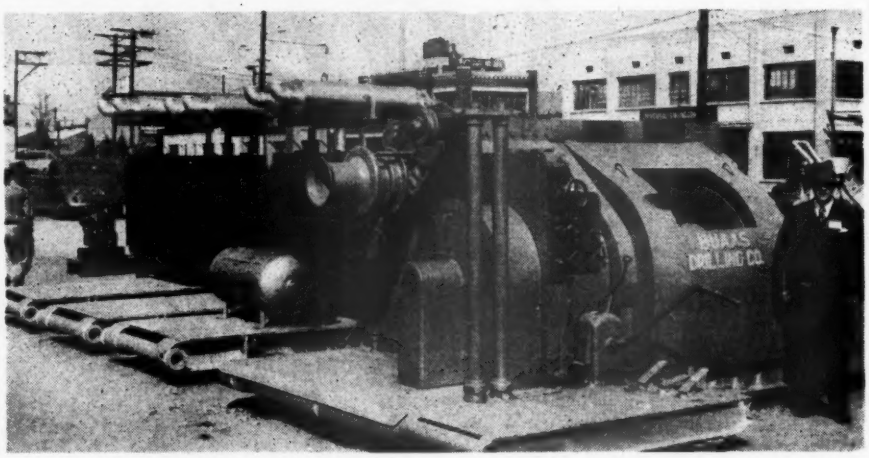


Walter Buaas standing beside drawworks and three twin diesels for new mechanical rig built for his company.

A NEW 10,000-ft. mechanical rotary drilling rig* at Los Angeles, California, was recently announced. The Walter Buaas Drilling Company of Bakersfield will use the rig in the San Joaquin Valley oil fields.

The blocks, substructure, rotary, kelly drive, swivel, unitized drawworks and drilling engines, and a 7¼-in. by 12-in. triplex pump were the major items placed on display in Los Angeles before the rig was put into use.

The unitized drawworks is powered by 3 twin diesel engine units. Each of the 3 diesel engine units combines the power output of two 6-cylinder diesel engines through a single output shaft. The diesels operate at 1600 r.p.m. as the output shaft turns at 900 r.p.m. The 3 engine units are rated at a little less than 300 hp. at the above speed for intermittent service. Some loss of power is experienced in the reduction and compounding transmission drives. A chain-driven transmission is built integrally with the hoist unit that enables the operator to change locations with one less unit of equipment than most other rigs. All units of equipment are within road width limitations imposed by many states despite this integration.

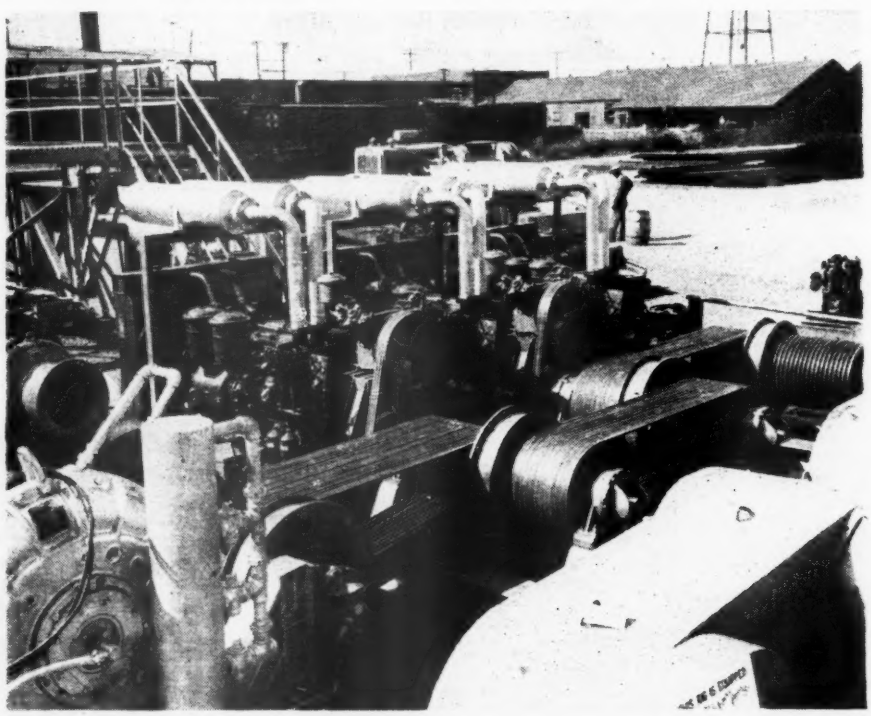
Smooth and flexible operation of the drawworks is effected by driving clutches of the air-friction type that are operated by controlled air pressure. These clutches have a tire-like rubber gland that expands or contracts as the air pressure is changed to engage or release the driving and driven members of the various power take-off and drum drives.

Control of the rig is maintained by regulation of the air-pressure. An air valve actuates the clutch to engage or release. All controls are centralized at the driller's position. The air glands have no moving parts requiring adjustment or lubrication. The use of such clutches with freely flexing sidewalls dampens vibration and absorbs shock as an automobile tire. Torsional capacity is regulated by controlling the air pressure.

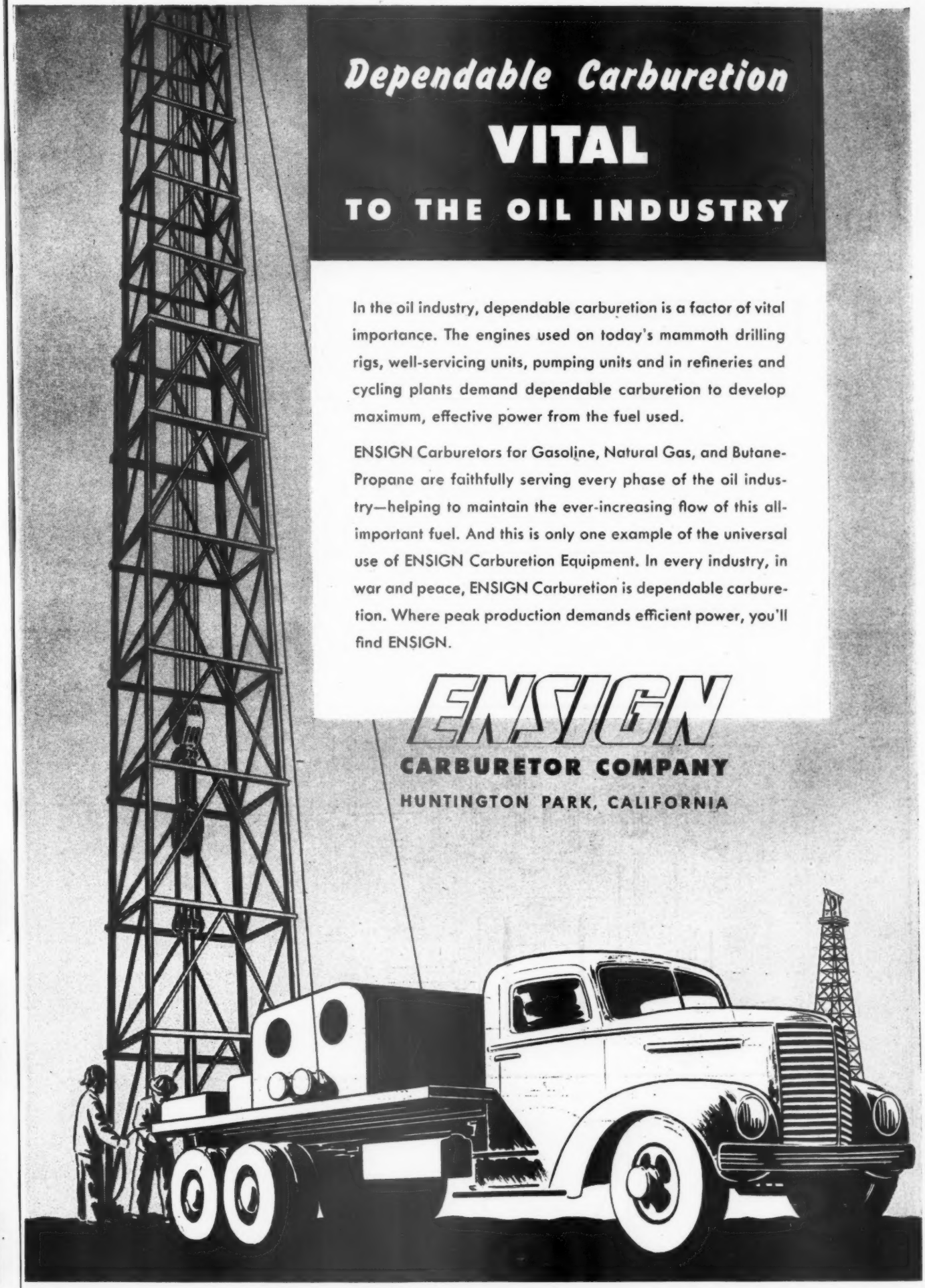
The clutch functions as a flexible coupling to compensate for any slight misalignment that might exist between driving and driven shafts. The design of the clutch tends to keep clutch pressure uniform. Uniform traction over the entire friction surface tends to distribute the wear. The clutches are air-cooled. Easily controlled air pressure regulates the torque. The clutch can be operated in such a way as to engage very gradually. These clutch characteristics are reflected in the operation of the hoisting unit, pump drive, and rotary drive. Primary and auxiliary air compressors are provided so that failure of one of the two air systems will not cause a shutdown of the rig. In addition, a low speed jaw clutch is provided on the drum for emergency purposes.

Multiple strand roller chain is used to drive all transmissions, the lineshaft, the primary rotary drive, and secondary

Engine transmission is V-belt driven. Housing has been set aside to show mechanism.



*Assembled by the International Derrick and Equipment Company, affiliated with The Dresser Industries.



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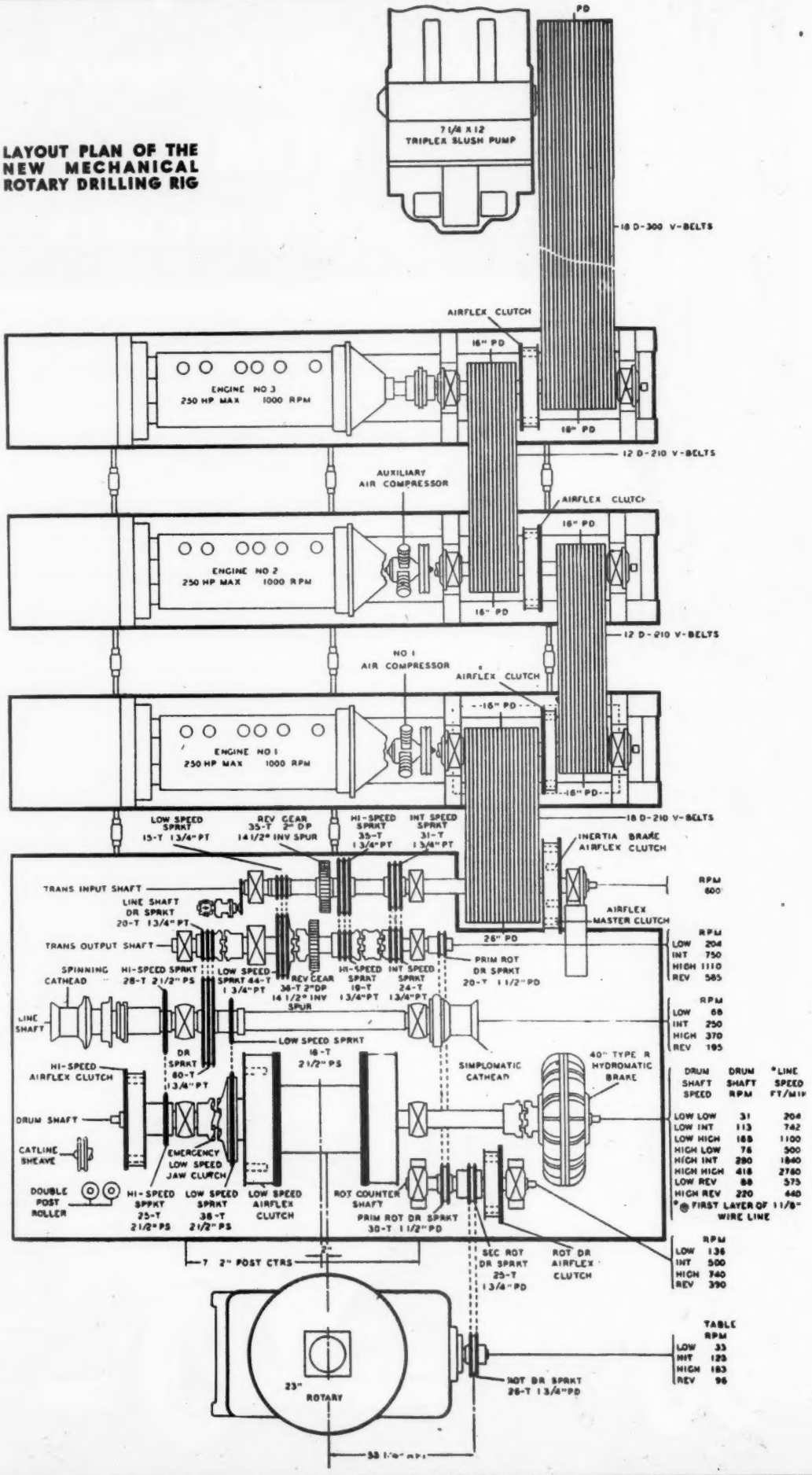

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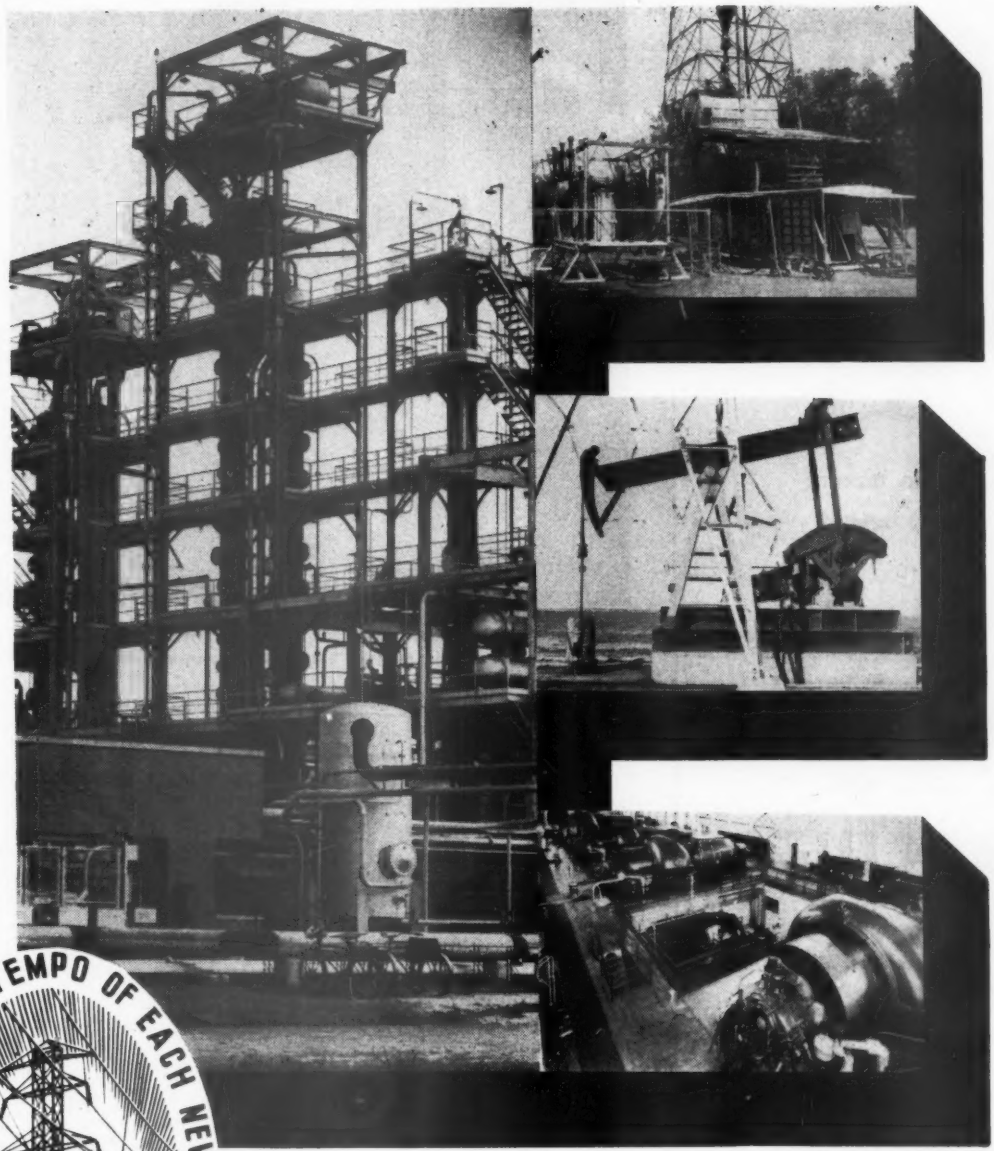

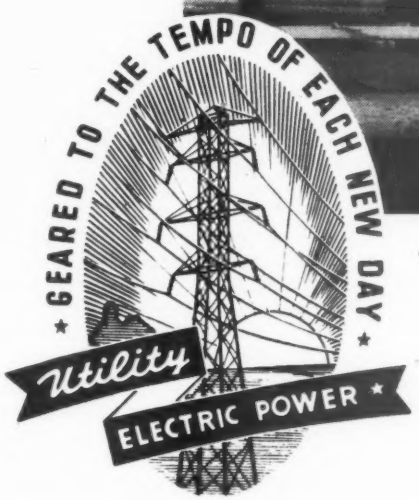

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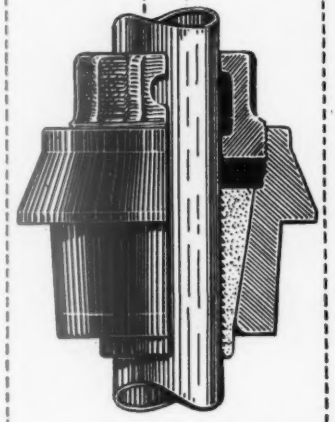

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3. The rig is rated at 750 hp., 7500 ft.-lb. torque.
4. Multiple strand chain drives enclosed in dust-proof, oil-bath housings are supplied. V-belt drives are also enclosed.
5. The transmission unit has 3 forward and 1 reverse speed.
6. The rig has high and low speed drives from the lineshaft. These drives combined with the transmission speeds give a total of 6 forward and 2 reverse speeds to the drum, and 3 forward and 1 reverse to the rotary table.
7. The drumshaft is 7⅛ in. in diam.; the lineshaft is 6¾ in. in diam., and the rotary countershaft is 6½ in. in diam.
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9. The hoist is equipped with a 24-in. by 32-in. special alloy steel drum with 10-in. by 46-in. brakes that are watercooled, torque equalized, micro-sensitized, and have an area of contact of 2170 sq. in. The coefficient of holding power is estimated to be 69 to 1.

A few of these new rigs have been in operation in the Mid-Continent area during the past year. One rig operated by the Stephens Petroleum Company of Oklahoma City in the West Edmond field is reported to have drilled 5500 ft. in 26 days. Another one operated by Jack Frazier of Houston was set up on a difficult bayou location north of Orange, Texas, and is credited with drilling a 9514-ft. hole in 47 days.

At another location near Winnie, Texas, Frazier's rig reportedly drilled a 9000-ft. wildcat in 35 days including 4 days spent working over and fishing for a stuck drill collar. In addition, considerable coring was done at this location. Frazier used natural gas for fuel, and a total of 684,000 cu. ft. was purchased at 10 cents per M. cu. ft., totaling $684.00. This is an average fuel cost of 7.6 cents per ft. of hole drilled.

During the time when the drilling crew was fishing for a stuck drill collar at a depth of 8500 ft., they latched onto the collar with an overshot and were pulling in an attempt to work the collar loose. The two back engines were killed and, with one engine running, the rig was credited with pulling the total weight of the pipe plus 50 points on the weight indicator. Although more power apparently was available, discretion dictated that 50 points more than the weight of the pipe was all the pull that was necessary under the circumstances. The drill collar was finally pulled with a friction hold inside a wash-over string, and the hole was drilled to 9000 ft.

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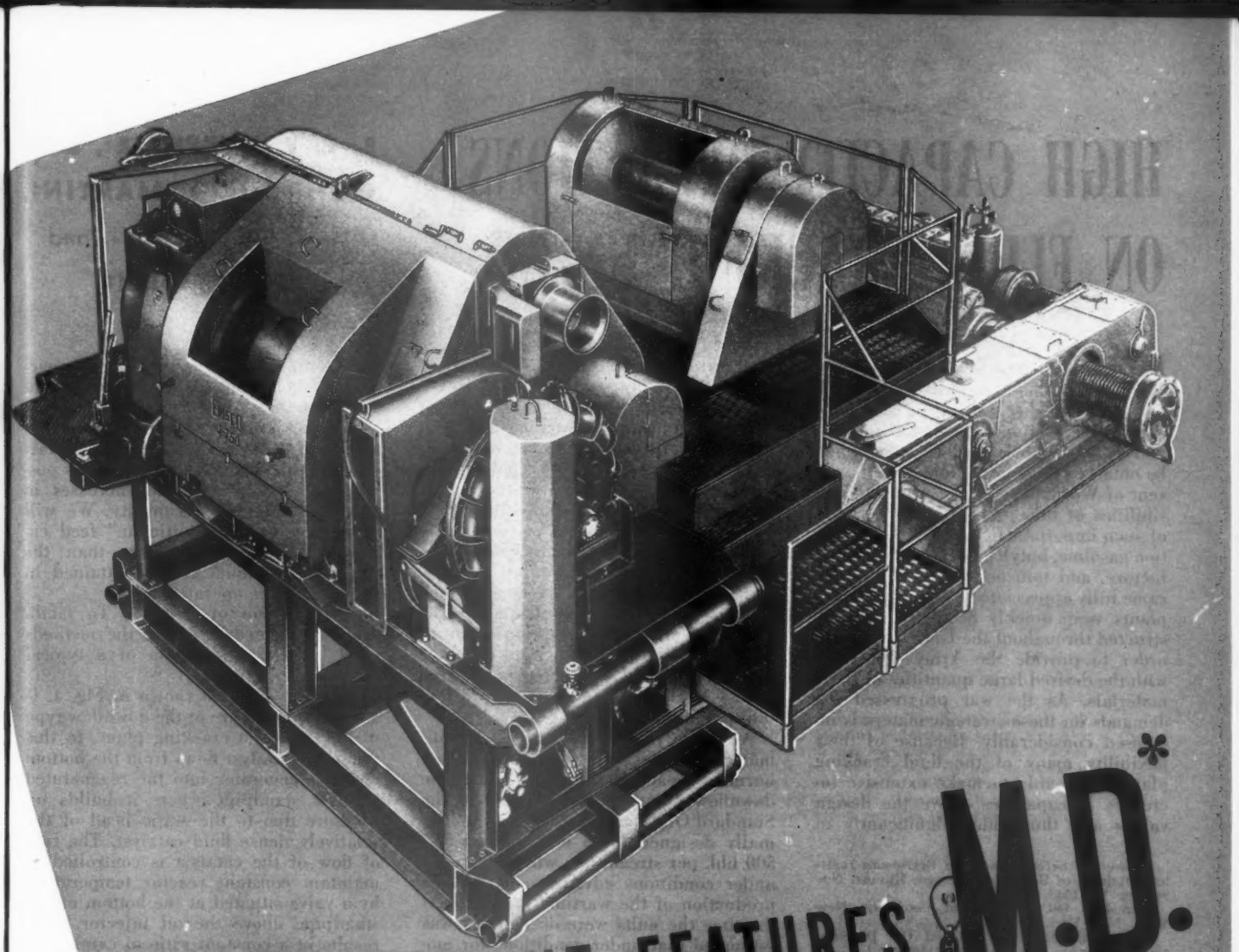

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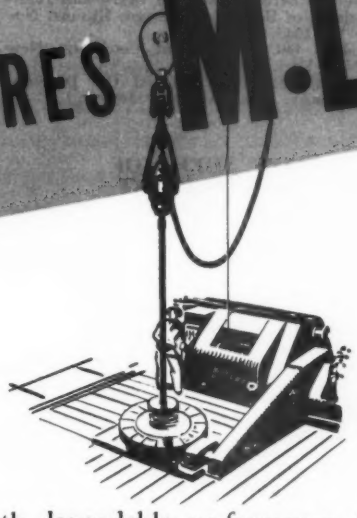

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HIGH CAPACITY OPERATIONS ON FLUID CRACKING UNITS*

By E. V. MURPHREE†, E. J. GOHR‡, H. Z. MARTIN‡, H. J. OGORZALY‡, and C. W. TYSON‡

FLUID catalyst cracking was developed originally by the Standard Oil Development Company as a means of increasing the yield and quality of motor gasoline and other salable products that could be obtained from crude oil. With the advent of World War II, however, the possibilities of this process for production of such important war materials as aviation gasoline, butylenes for rubber manufacture, and toluene for explosives, became fully appreciated. As a result many plants were quickly designed and constructed throughout the United States in order to provide the Army and Navy with the desired large quantities of these materials. As the war progressed the demands for these strategic materials increased considerably. Because of their flexibility many of the fluid cracking plants were able to make extensive increases in capacities above the design values and thus aided significantly in preventing a shortage of petroleum products.

There are in operation at the present time 34 fluid catalyst cracking units and about 9 additional plants are undergoing design or construction. Of this total of 43 plants, all but 6 are in the United States. The nominal design cracking capacity for these plants is about 540,000 bbl. per stream day, in many cases based on the more severe operations for production of aviation gasoline components. It is estimated, however, that under the less severe operating conditions that are best suited for maximum yield of motor gasoline the total feed capacity of these plants would be approximately 720,000 bbl. per stream day.

As stated above, these values are estimated on the basis of the design carbon burning capacities of these plants. The downflow plants of the affiliates of the Standard Oil Company (N.J.) were originally designed for a feed rate of 15,500 bbl. per stream day when operating under conditions advantageous for the production of the wartime products. At the time the units were designed it was estimated that under conditions for motor gasoline production the feed capacity would be about 20,000 bbl. per stream day. It is the purpose of this article to describe the means by which limitations were overcome so that while making wartime products in these plants it was possible to make significant increases in feed and production capacity. We will also show how an "ultimate" feed capacity considerably greater than the wartime maximum can be attained in motor gasoline operations.

● **Description of Process.** To facilitate the understanding of the methods used, a brief description of a typical plant will be given.

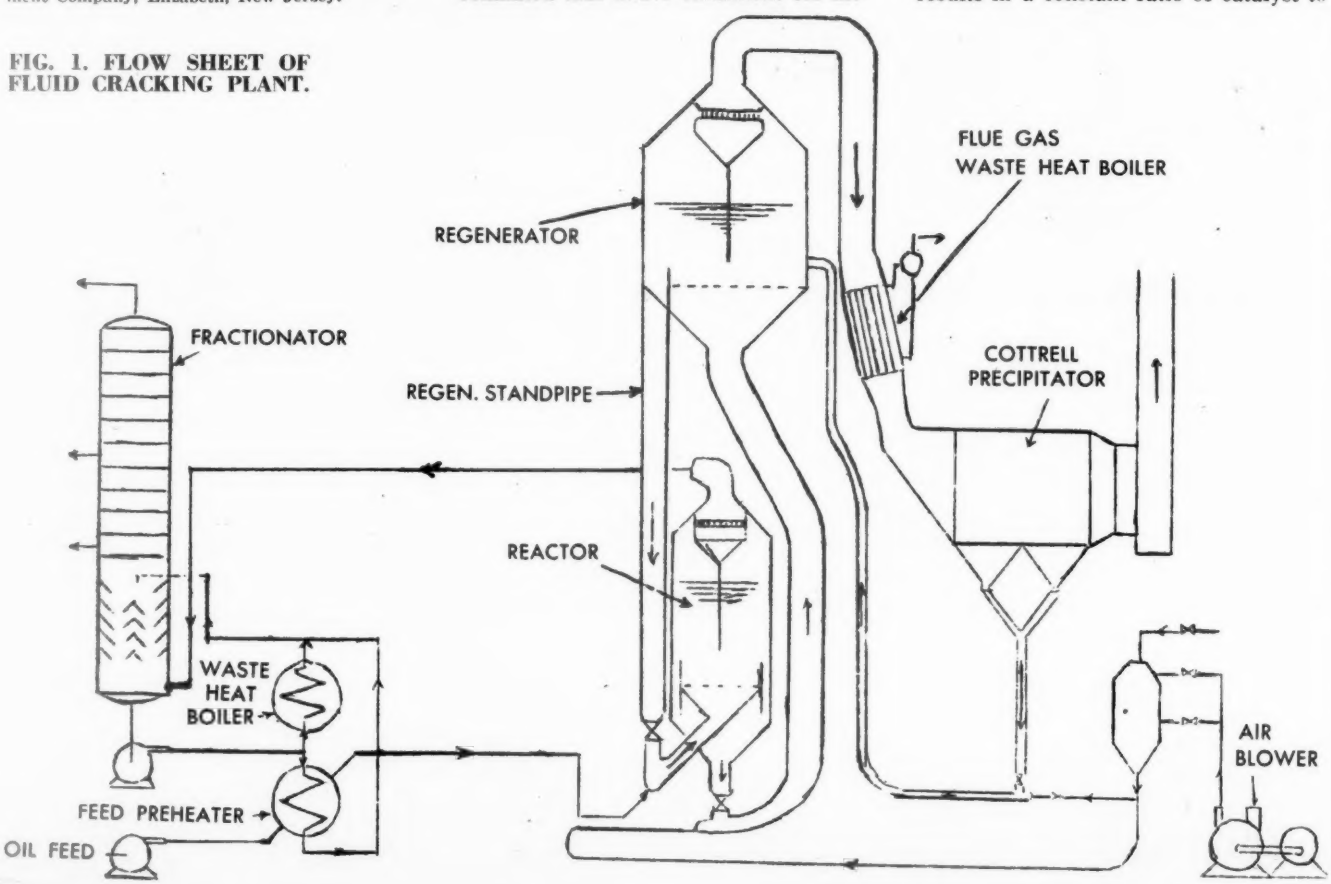
The flow diagram shown in Fig. 1. is a simplified picture of the downflow type of fluid catalyst cracking plant. In this plant hot catalyst flows from the bottom of the regenerator into the regenerated catalyst standpipe where it builds up pressure due to the static head of the relatively dense fluid catalyst. The rate of flow of the catalyst is controlled to maintain constant reactor temperature by a valve situated at the bottom of the standpipe above the oil injector. This results in a constant ratio of catalyst to

*Presented before American Petroleum Institute Division of Refining, Chicago, Illinois, November 15, 1945.

†Standard Oil Development Company, New York, New York.

‡Esso Laboratories, Standard Oil Development Company, Elizabeth, New Jersey.

FIG. 1. FLOW SHEET OF FLUID CRACKING PLANT.



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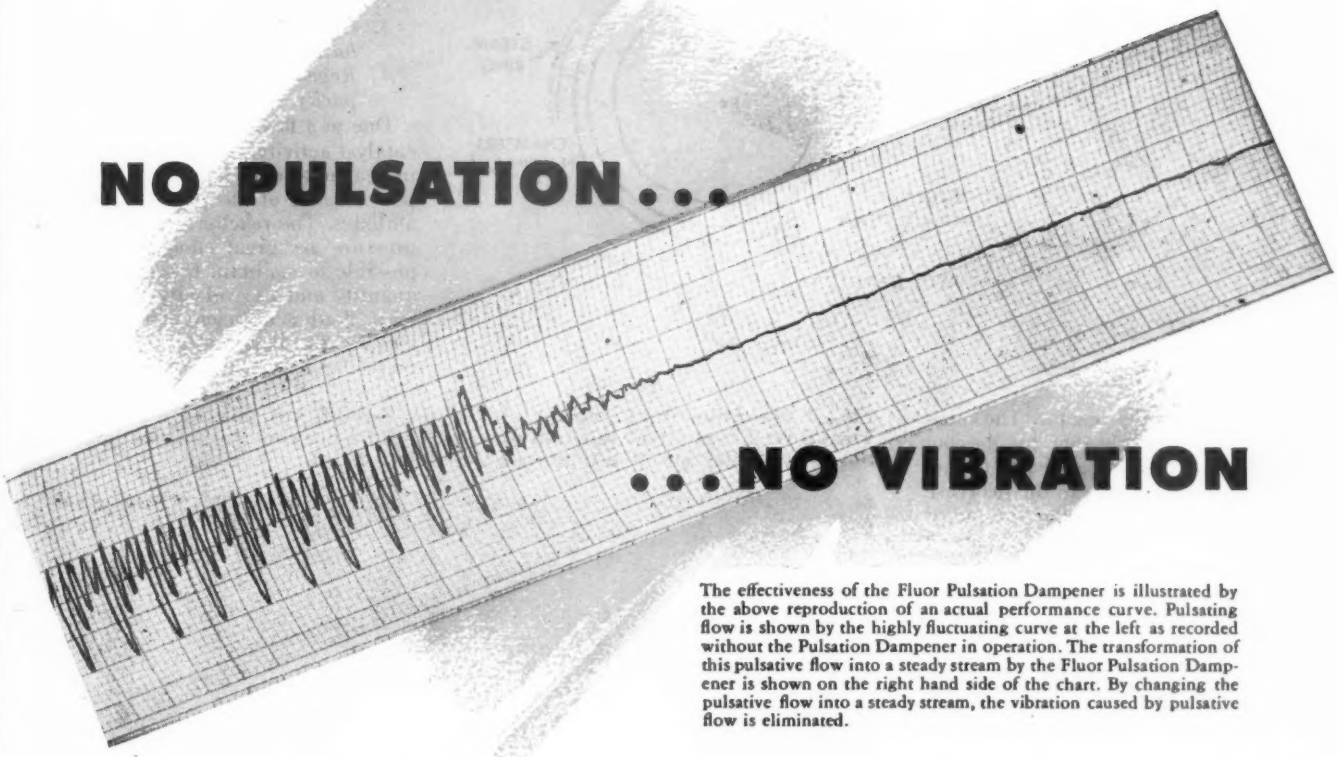

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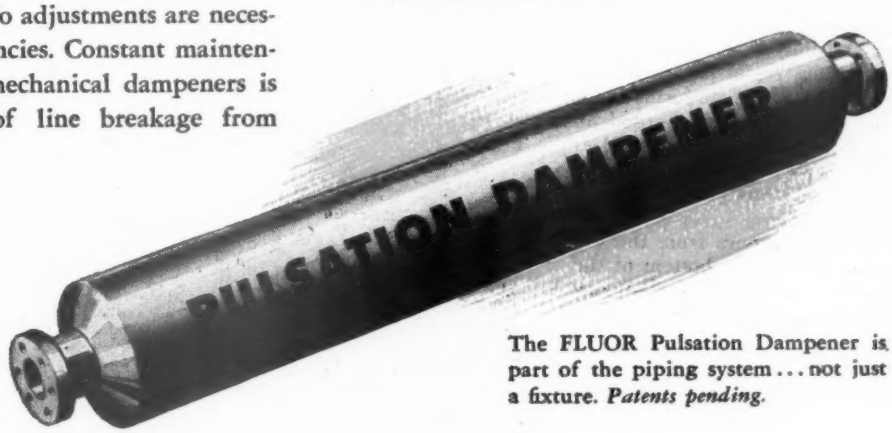

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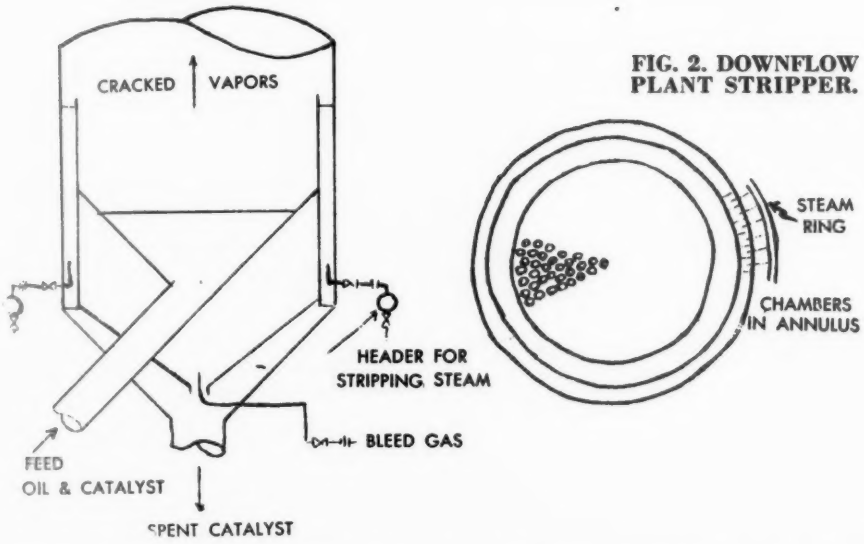


FIG. 2. DOWNFLOW PLANT STRIPPER.

oil being fed into the reactor. The oil is vaporized and superheated by the hot catalyst, which is then carried to the reactor by the vapors. Due to the decrease in gas velocity in the reactor the major portion of the catalyst settles out into a dense bed, and only a fractional per cent of the catalyst circulated is carried out of the reactor with the cracked vapors. Practically all the catalyst carried overhead is returned to the system by means of recovery equipment. The spent catalyst flows downward through the annular zone at the bottom of the reactor, where a flow of steam strips out entrained oil vapors, and into the standpipe where it again forms a pressure leg above a control valve. The catalyst flow through this valve is regulated to maintain the reactor catalyst level at a constant value. The reactor catalyst level may be varied at will to obtain whatever degree of conversion is desired.

The catalyst flowing through the control valve is picked up by air in the injector and carried to the regenerator. Here the catalyst again settles out in a dense bed, and only a small fraction is carried out of the vessel to catalyst recovery equipment. The coke formed during the cracking reaction is burned off in the regenerator, and the catalyst, after regeneration, flows into the regenerated catalyst standpipe, thus completing the cycle.

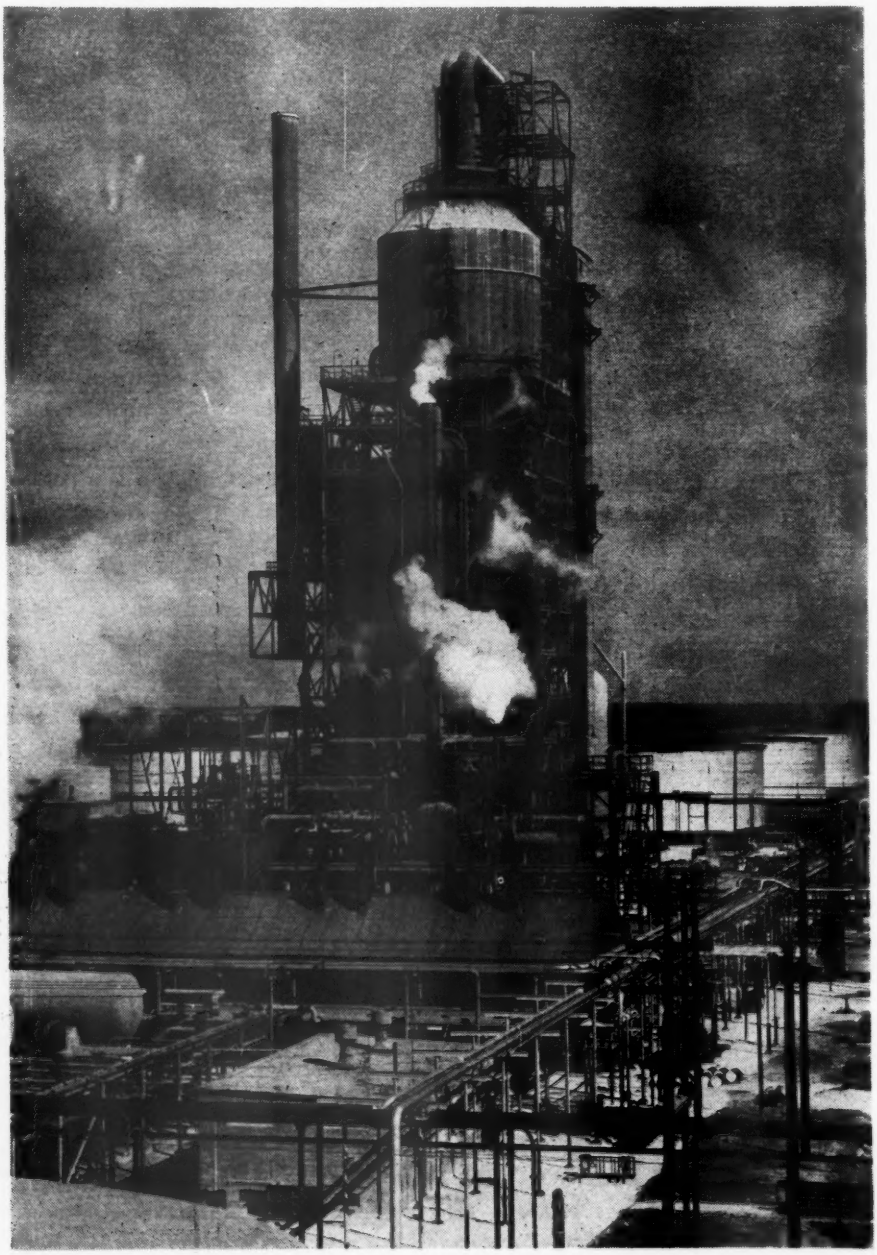
The cracked oil vapors from the top of the reactor flow to the bottom of the fractionator. Here a recirculated stream of the bottoms flows down over disk-and-donut baffles and scrubs the last traces of entrained catalyst particles from the rising vapors. This bottoms stream also removes heat from the vapors and then passes through a series of heat exchangers where it gives up heat in part to the fresh feed, any excess being used to produce high pressure steam. The catalyst picked up by the bottoms is removed by withdrawal of a small portion of the circulating stream to a Dorr thickener where about 70 per cent of the heavy oil is separated from the catalyst. The thickened sludge from the bottom of the settler is diluted with fresh feed and pumped to the reactor inlet to return the catalyst to the system.

● **Plant limitations.** The basic factors that affect plant capacity may be summarized as follows:

1. *Cracking capacity.*
2. *Feed preheat capacity.*
3. *Carbon-feed stock conversion relationship.*
4. *Regenerator carbon burning capacity.*

Due to a flexible design and adequate catalyst activity maintenance, the cracking capacity does not normally limit the performance of the plants of the Jersey affiliates. The reactor size and allowable pressure are great enough so that it is possible to maintain reasonable catalyst quantity and gas velocity in that vessel. Also, there is sufficient spare heat in the fractionator bottoms to provide the increase in feed temperature required to

FIG. 3. Downflow fluid cracking unit of the Humble Oil and Refining Company. The oil feed capacity of this unit was increased 80 per cent during wartime operations for production of aviation gasoline components.



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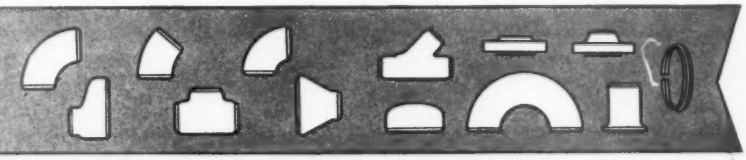

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FIG. 4. Operating control room of downflow fluid cracking unit, Baltimore refinery.

maintain reactor temperature as the feed rate is increased. During wartime these plants have been operated to catalytically crack the amount of oil consistent with the maximum amount of carbon that can be burned in the regenerator.

With carbon burning capacity limiting there are 2 basic means by which the capacity of a fluid catalyst plant can be increased: (a) Improving the carbon-conversion relationship, that is, the relationship between the yield of carbon based on feed and the extent to which the feed is catalytically cracked, and (b) by alteration of the conditions that limit regeneration capacity so that a greater carbon burning rate is possible. Both methods have been utilized in the plants of the Jersey affiliates and will be discussed more fully below.

● **Improving carbon-conversion relationship.** Two methods for improving carbon-conversion* relationship have been applied. One of these involves the efficiency of removal of the entrained hydrocarbon vapors that are carried down from the reactor into the stripper in the interstitial space between the catalyst particles. If allowed to remain long in contact with the catlyst in the stripper this material can become severely cracked and lay down much unstrippable carbon. Therefore, it is advantageous to remove these vapors as quickly and completely as possible. Improvement of stripper efficiency has been successful in reducing the hydrocarbon carryover to the regenerator by an amount equivalent to approximately 0.5-0.7 per cent carbon by weight based on feed. This improvement has been attained by the installation of long, thin box-like cells in the annular stripping section, as shown in Fig. 2.

Because stripping of the catalyst is not entirely complete, even in the improved stripper, further improvement in carbon-conversion relationship is obtained by reduction of the ratio of catalyst to oil fed. It is obvious that the same amount of heat can be transferred from the regenerator to the reactor either by a high catalyst rate with a low difference in temperature between the two vessels or by a low catalyst rate and a high temperature difference. Therefore, for a given reactor temperature the catalyst-to-oil ratio may be decreased by raising the regenerator temperature. Through operating experience it has been determined that the regenerators of commercial plants can be operated satisfactorily in the range from 1100 to 1150°F. All early regeneration was carried out at 1050 to 1075°F. A typical example showing the effect of an increase in regeneration temperature on catalyst-to-oil ratio and carbon yields follows:

Regenerator temperature, °F.	1050	1150
Reactor temperature, °F.	950	950
Oil preheat temperature, °F.	430	560
Catalyst-oil ratio	23	10
Conversion, vol., per cent	62	62
Carbon on feed, wt., per cent	6.2	5.3

Under conditions of operation in which regenerating capacity is limiting, as is frequently the case, it is evident, as in the above example, that the fresh feed charge capacity can be increased 15-20 per cent by reason of the reduction in carbon yield at the lower catalyst-to-oil ratio. It is necessary to supply more preheat in the oil feed to maintain the same cracking temperature because of the smaller amount of carbon burned per unit of feed.

● **Increasing regeneration capacity.** The above-mentioned increase in regenerator temperature has increased the efficiency of regeneration due to its beneficial effect on burning rate. Also, for a given contact time in the regenerator a larger proportion of the oxygen may be utilized. In early operations more excess air was required and the oxygen concen-

*In this article conversion is defined as the per cent of the gas oil in the feed that is catalytically cracked, with gas oil taken as fraction boiling above 400°F. end point gasoline.

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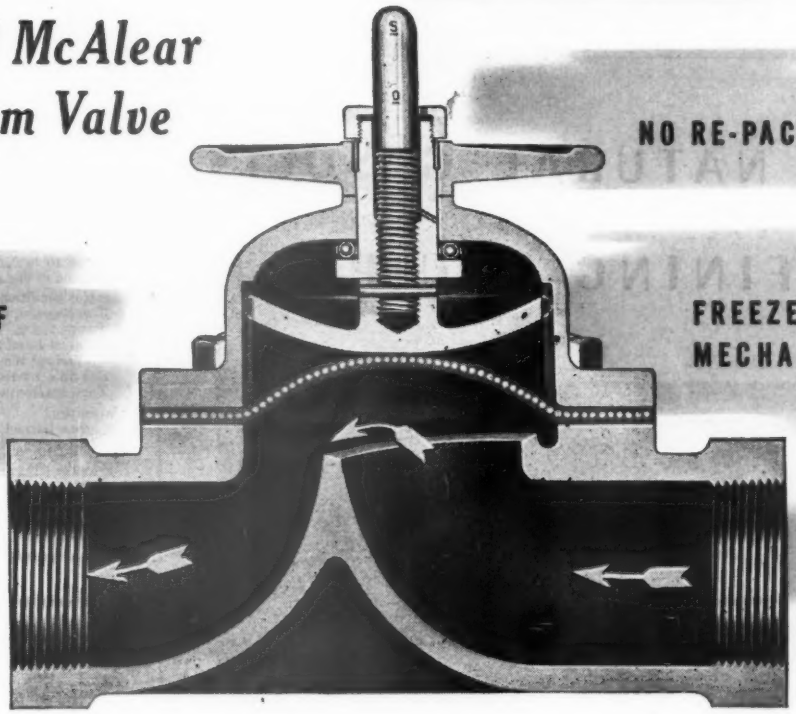

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tration in the flue gases averaged 2.0 to 3.0 per cent. High temperatures have brought this value down to about half the former amount, resulting in higher carbon burning capacity.

Other important factors have entered into the improvement of regeneration capacity, however. Pilot plant test data had shown that catalyst entrainment in flue gases rising from the dense bed increased rapidly when normal gas velocity was exceeded. Further increase in burning capacity without increase in gas velocity can be obtained by increasing the regenerator pressure, however.

The following tabulation of calculated figures shows how regeneration capacity can be increased by the means discussed above:

Regeneration pressure, lb. per sq. in. gage.	0.5	5.0
Regenerator temperature, °F.	1,050	1,125
Air rate, std. cu. ft. per min.	45,000	55,000
Oxygen in flue gas, vol. per cent (dry).	2.4	1.2
Carbon burning capacity, lb. per hr.	13,000	16,900

Thus a gain in carbon burning capacity of 30 per cent is attainable in the above example. The values presented above were estimated on the basis of no change in hydrogen-to-carbon ratio in the coke carried to the regenerator. However, the improved stripper reduces the ratio such that an additional gain of 15-20 per cent in carbon burning capacity is possible due to the fact that less oxygen is diverted to the combustion of hydrogen.

Except for the stripper improvements only minor equipment changes, such as rearrangement of fractionator bottoms heat exchangers in boiler and feed-preheat service, are required to take care of the increased capacity. Increases in velocity in the reactor and fractionator tower are avoided by raising the pressure on this equipment.

● **Representative plant data.** A concrete illustration of the results obtainable by the methods discussed is available in operating data from the downflow fluid catalyst plant of the Humble Oil and Refining Company. Table 1 shows

TABLE 1
Humble Oil and Refining Company downflow fluid cracking unit, aviation gasoline operation.
Operating data.

	August, 1944	June, 1945
Regeneration conditions		
Top pressure, lb. per sq. in. gage	1.8	5.0
Temperature, °F.	1,055	1,125
Air blower discharge pressure, lb. per sq. in. gage	14.0	11.8
Total air rate, std. cu. ft. per min.	45,700	54,800
Oxygen in flue gas, vol. per cent (dry)	2.4	1.2
Reactor conditions		
Top pressure, lb. per sq. in. gage	10.0	17.5
Temperature, °F.	954	948
Catalyst-to-oil ratio	20.8	10.7
Oil preheat temperature, °F.	390	543
Gas oil conversion, vol. per cent	62.1	61.5
Total reactor steam, lb. per hr.	17,200	9,500
Capacities		
Carbon burned, lb. per hr.	13,100	18,800
Oil feed rate, bbl. per stream day	16,400	28,000

the operating data from this plant for the months of August, 1944, and June, 1945. These are typical periods representing operation before and after installation of the improved stripper. On the regeneration side (a) the regenerator pressure has been increased from 1.8 to 5.0 lb. per sq. in. gage, (b) the temperature from 1055°F. to 1125°F., (c) the blower discharge pressure lowered from 14.0 to 11.8 lb. per sq. in. gage, and (d) the oxygen concentration in the flue gas has decreased from 2.4 to 1.2 per cent. The resulting increase in air rate and in oxygen utilization, combined with the effect of the improved stripper on hydrogen content of the coke, made possible a 43 per cent increase in carbon burning capacity, that is, from 13,110 to 18,800 lb. per hr.

On the reactor side it will be observed that, (a) although there is little difference in catalytic gas oil conversion between the two sets of data, the improved stripper aided by a decrease in catalyst-to-oil ratio reduced the carbon yield from 6.4 to 5.4 per cent, (b) the reactor temperature was maintained approximately constant by reason of the higher oil inlet temperature, and (c) the reactor gas velocity was kept at a reasonable level by an increase in pressure from 10 to 17.5 lb. per sq. in. ga. and also by a decrease in process steam. Thus it was possible to increase the plant feed capacity from 16,400 to 28,000 bbl. per stream day with little change in the proportion of the gas oil cracked to lighter products.

(Continued on Page 146)

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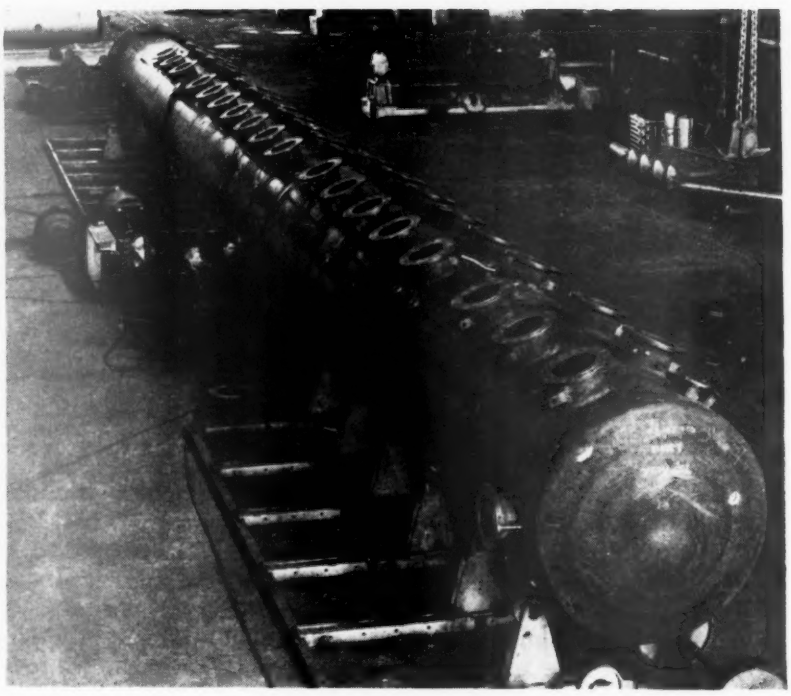

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(Continued from Page 142)

Table 2 shows the yields obtained. The improved product distribution shown by the recent data may be partly due to the lower amount of steam used. It has been found that steam affects some of the light hydrocarbon yields. Thus less dry gas and butanes are formed, and a larger proportion of the cracked products are found in the motor gasoline range. A small part of the increased gasoline yield is due to a higher (4.0 per cent vs. 2.0 per cent) naphtha concentration in the feed.

In Table 2 there are also summarized the production rates and octane number of 10-lb. catalytically cracked gasoline and also of 10-lb. motor gasoline based on non-selective polymerization of all recoverable propylene and butylenes and pressuring of the gasoline with catalytic butanes. It will be observed that the production of gasoline has increased 82 per cent with little or no loss of quality. Also, despite the lower yield of butanes in the recent operation, the volume of excess butane available after pressuring the gasoline mixture is slightly greater than that for the early operation.

● **Capacity ultimately attainable.** In the mechanical design for the first commercial fluid catalytic cracking plants it was necessary to make allowance for the possible effects of high temperatures and erosion on the life of the vessels and lines. As experience has shown that the high temperatures and erosion can be easily controlled within limits that make the original allowances conservative, it is possible to take advantage of this overdesign by operation at even more severe conditions than is presently done.

In these plants the mechanical strength of the regenerator limits the system pressure that can be used. Therefore the ultimate capacity of the plant is set by the amount of air that can be utilized at normal gas velocity in the top of the regenerator at this limiting pressure. In these figures we have taken 12.5 lb. per sq. in. gage as the maximum pressure obtainable, although preliminary investigations now indicate that further increase may be possible. Table 3 shows the estimated plant capacity based on the 12.5 lb. per sq. in. gage regenerator top pressure. Under these conditions the carbon burning capacity is increased about 20 per cent above that attainable with a 5 lb. per sq. in. gage regenerator pressure and is more than 70 per cent higher than the design value.

Although the yields are estimated for motor gasoline operation, that is, at 50

TABLE 2

Humble Oil and Refining Company downflow fluid cracking unit, aviation gasoline operation.

Yield and quality of products.

	August, 1945	June, 1945
Feed rate, bbl. per stream day	16,400	28,000
Gravity, deg. API	30.2	29.9
Mid boiling point, °F.	625	623
Yields, based on feed		
Dry gas, wt. per cent	12.0	10.4
Total C_4, vol. per cent	17.7	15.6
Butylenes	8.2	8.0
C_5-430°F. VT*	34.4	38.9
Cycle oil	37.1	37.0
Carbon, wt. per cent	6.4	5.4
10-lb. catalytic cracked motor gasoline		
Yield, vol. per cent of feed	36.2	40.8
Bbl. per stream day	5,940	11,400
ASTM octane no., clear	81.6	81.5
CFR-R octane no., clear	95.2	95.0
10-lb. catalytic cracked gasoline plus polymer		
Yield, vol. per cent of feed	46.8	49.9
Bbl. per stream day	7,670	14,000
ASTM octane no., clear	82.0	81.8
plus 1.5 cc. TEL	85.4	85.3
CFR-R octane no., clear	96.3	96.1
plus 1.5 cc. TEL	99.5	99.3
Excess butanes, vol. per cent of feed	6.4	4.3
Bbl. per stream day	1050	1200

*Equivalent to debutanized 400° end point naphtha.

TABLE 3

Expanded plant capacity compared with previous operations.

Operating conditions.

	August, 1944	June, 1945	Expanded operation
Regenerator conditions			
Top pressure, lb. per sq. in. gage	1.5	5.0	12.5
Temperature, °F.	1,055	1,125	1,100
Blower discharge pressure, lb. per sq. in. gage	14.0	11.8	22
Total air rate, std cu. ft. per min.	45,700	54,800	72,500
Oxygen conc. in flue gas, vol. per cent (dry)	2.4	1.2	2.0
Reactor conditions			
Top pressure, lb. per sq. in. gage	10.0	17.5	22
Temperature, °F.	954	948	950
Catalyst-to-oil ratio	20.8	10.7	9.5
Oil preheat temp., °F.	390	543	675
Gas oil conversion, vol. per cent	62.1	61.5	50
Capacities			
Carbon burned, lb. per hr.	13,110	18,800	22,500
Oil feed rate, bbl. per stream day	16,400	28,000	42,000

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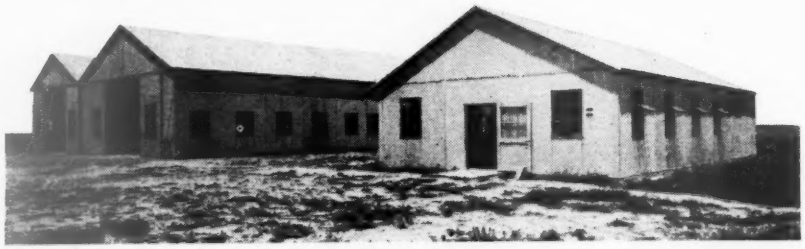

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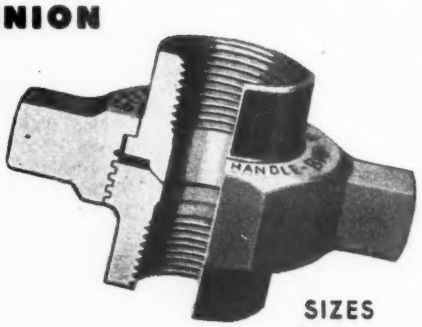

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per cent conversion, and are not strictly comparable with the previous data quoted above, which were at higher conversions primarily for production of aviation gasoline components, a comparison is made in Table 4 with the data of the low and high capacity runs at the Humble plant. It will be observed that there is a further possible increase in feed capacity to 42,000 bbl. per stream day. The daily motor gasoline plus polymer production is increased 152 per cent and 38 per cent above those of the low and high feed rate cases, respectively.

TABLE 4

Expanded plant capacity compared with previous operations.

Yield and quality of products.

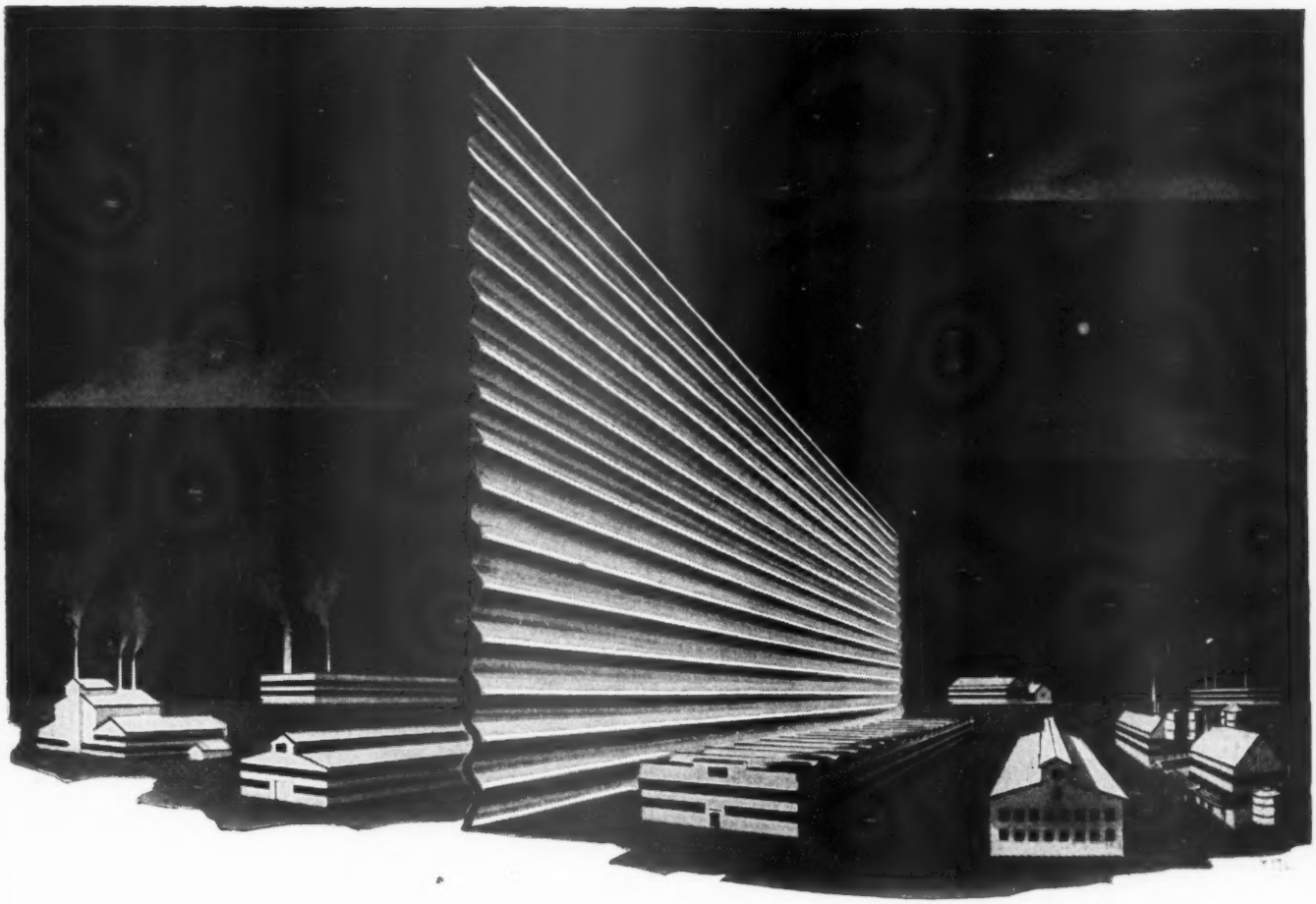
	August, 1944	June, 1945	Expanded operation
Feed rate, bbl. per stream day.	16,400	28,000	42,000
Yields, based on feed			
Dry gas, wt. per cent	12.0	10.4	7.2
Total C_4, vol. per cent	17.7	15.6	10.2
C_5-430°F. VT	34.4	38.9	36.5
Cycle oil	37.1	37.0	48.0
Carbon, wt. per cent	6.4	5.4	4.1
10-lb. R.v.p. catalytic cracked motor gasoline			
Yield, vol. per cent	36.2	40.8	38.4
Bbl. per stream day	5,940	11,400	16,100
ASTM octane, no., clear	81.6	81.5	81.0
CFR-R octane no., clear	95.2	95.0	94.6
10-lb. R.v.p. catalytic cracked gasoline plus polymer			
Yield, vol. per cent	46.8	49.9	46.0
Bbl. per stream day	7,670	14,000	19,300
ASTM octane no., clear	82.0	81.8	81.5
plus 1.5 cc. TEL	85.4	85.3	85.0
CFR-R octane no., clear	96.3	96.1	95.5
plus 1.5 cc. TEL	99.5	99.3	99.0
Excess butanes, vol. per cent of feed	6.4	4.3	0
Bbl. per stream day	1,050	1,200	0

Due to the less severe conditions that are optimum for motor gasoline production, a lower butanes yield is obtained and all of it is needed for pressuring the gasoline. Also, the octane numbers of the resulting blends are slightly lower than those from the higher conversion operations.

To attain these expanded capacities some changes must be made in certain parts of the equipment. The most important of these are the installation of new air compression equipment, spent catalyst stripper alterations, reinforcing of catalyst recovery equipment, installation of a preheat furnace, and increasing the exchanger surface and pumping facilities in the fractionation section. The cost of these changes is relatively small, however, when expressed as dollars per barrel of incremental feed capacity. This figure is estimated to be less than $100 per bbl. per stream day of charge stock.

It is believed that further improvements in fluid operation are possible. Additional studies are being carried out to determine the factors that affect stripping and carbon deposition. That improvements in carbon-conversion relationship are possible in commercial plants has been indicated by the results of pilot plant tests. The results of these and other studies should add to the advantages of the use of fluid catalytic cracking in the refining of petroleum.

★ ★ ★



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RECONDITIONING NORTH OKLAHOMA PIPE LINE

EXCLUSIVE Petroleum Engineer Picture Story

By **WILLIAM J. DAVIS**

Recently Shell Pipe Line Company reconditioned 30 miles of one of the oldest lines in its extensive pipe line system. Built to serve the urgent needs of World War I, the line had as its terminal the city of Chicago and delivered its first crude there in 1917. The reconditioning of the 10-in. screw line began at Shell's Cushing, Oklahoma, station and ended at the Arkansas River crossing near Cleveland, Oklahoma. The work was under the supervision of R. L. Robards, chief inspector for Shell.

An unusual method was used to recondition the line with a minimum of down time of the pipe line. Twelve miles of new pipe were laid parallel and on the same right-of-way with the pipe to be reconditioned. This new pipe was tied in to the old line at the 10-mile point and crude oil routed through it from the Cushing station. While the remaining two miles were being laid, take-up operations were begun on the old pipe that was now free from operational duties. A rooter was used to dig out the old pipe, which was taken to a conditioning yard set up mid-way between the ends of the 30-mile section. Once the conditioning yard had begun to turn out finished pipe, the take-up and laying crews worked simultaneously with no lay-offs. The tying-in periods were reduced to three, each of a few hours' duration, during the 50-day work period, resulting in maximum use of the line.

FIG. 1. W. B. Williams, superintendent of construction for H. C. Price Company, contractors on the Shell job, and R. L. Robards, chief inspector for Shell, discuss details of the work.

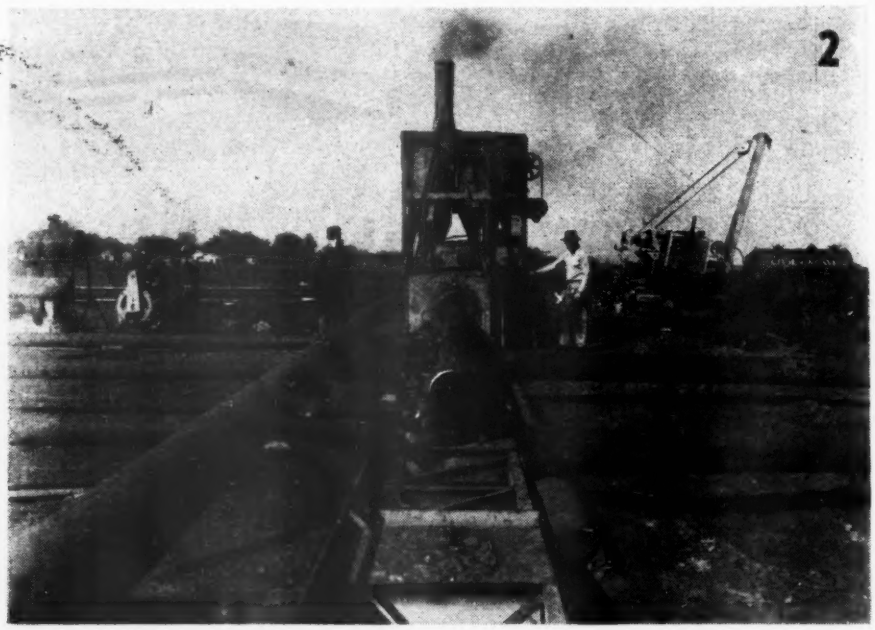

FIG. 2. Shot-blasting machine was used for final cleaning of pipe before primer coat was added. Reconditioning yard worked on 24-hour basis that set the pace for pick-up and laying crews on the main line. Pipe was returned to right-of-way for relaying.

FIG. 3. A ditch-digger was used when terrain and soil conditions permitted to prepare ditching for conditioned pipe to lay along side of operating line.

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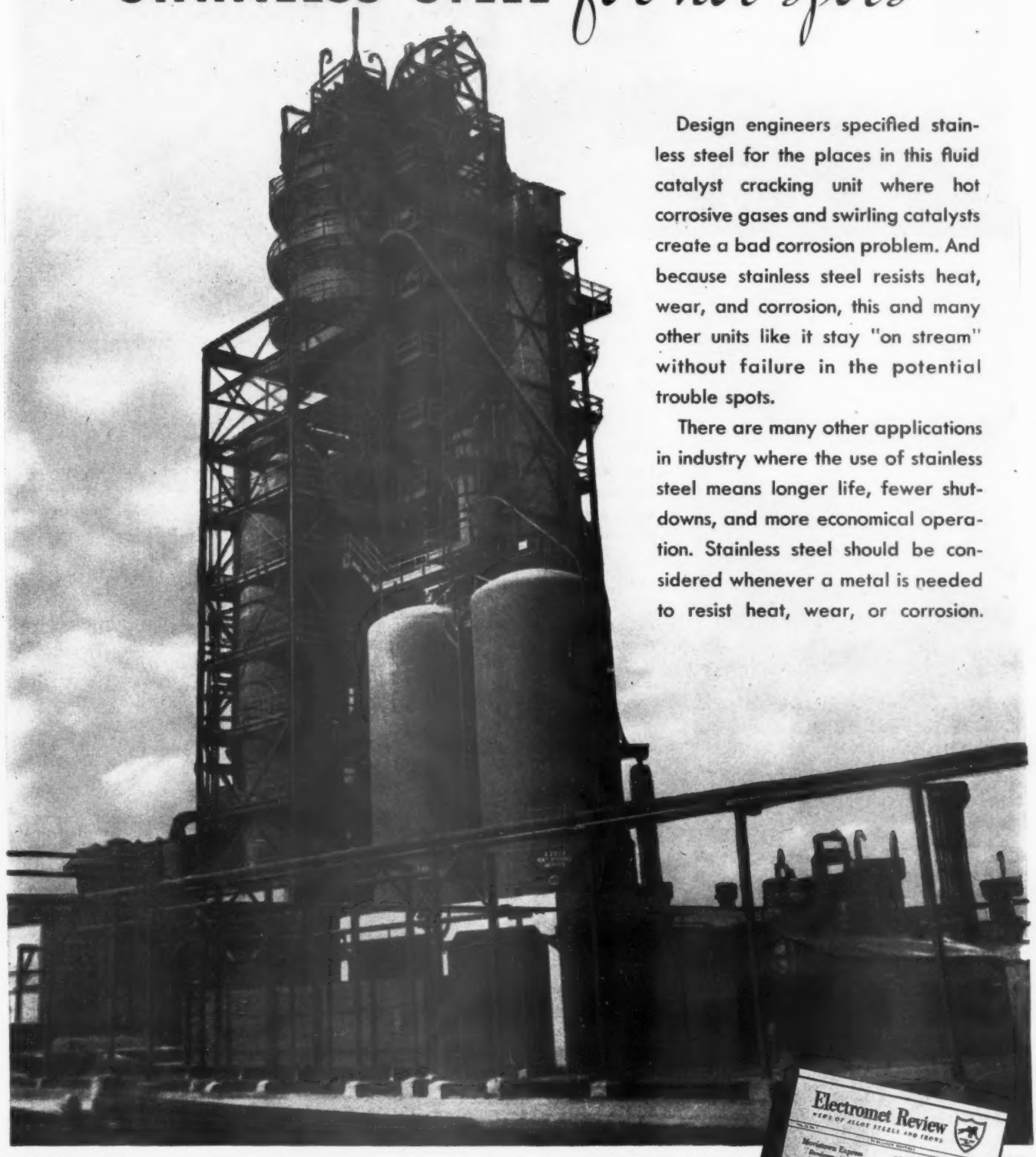

Design engineers specified stainless steel for the places in this fluid catalyst cracking unit where hot corrosive gases and swirling catalysts create a bad corrosion problem. And because stainless steel resists heat, wear, and corrosion, this and many other units like it stay "on stream" without failure in the potential trouble spots.

There are many other applications in industry where the use of stainless steel means longer life, fewer shutdowns, and more economical operation. Stainless steel should be considered whenever a metal is needed to resist heat, wear, or corrosion.

Other interesting uses of stainless steel are described in ELECTROMET REVIEW, published by ELECTRO METALLURGICAL COMPANY, the Unit of UNION CARBIDE AND CARBON CORPORATION that produces alloys for making steel. If you need this complimentary publication, write on your business letterhead to ELECTRO METALLURGICAL COMPANY, Room 328, 30 East 42nd Street, New York 17, N. Y.

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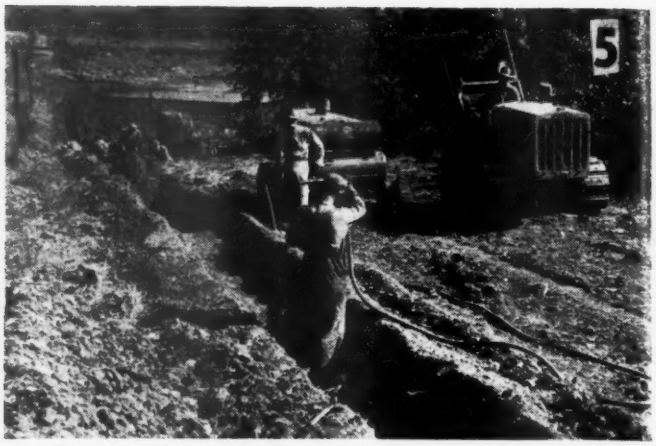


FIG. 4. It isn't always easy going for the ditcher and explosives have to be used to open a way for the line. Blasting operations must be carried on well in advance of other pipe-line activities to provide maximum safety and clean-out time.

FIG. 5. Shaping up with pneumatic paving breakers after the explosion and drilling more shot holes slowly works the ditch down to a suitable depth. Keeping ditch open and well drained during inclement weather requires careful planning and execution of work.

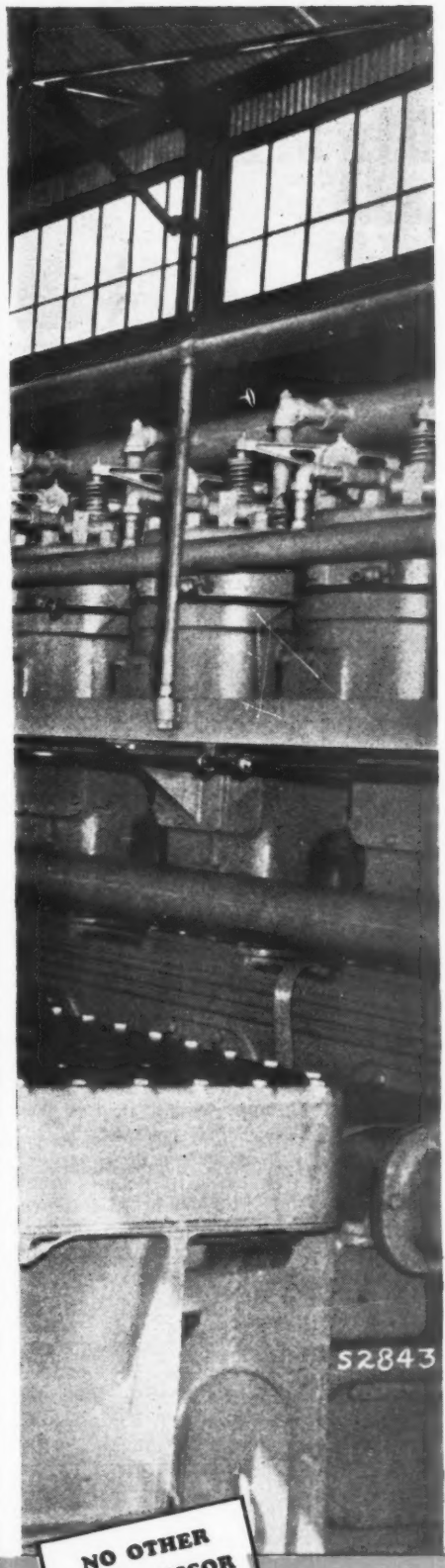
FIG. 6. A welder and his helper complete a butt-weld on the main line. Side-boom tractors have placed double joints in welding position on skids over the ditch.

FIG. 8. Hot coating was applied to the line with the aid of a side-boom tractor followed by wrapping before lowering and covering the line. The 30-mile section of pipe was completed in 50 working days interspersed with bad rains, totaling 10 lost working days.

THE END

FIG. 7. More than 25 welding machines and welders were used on the main line to keep laying operations at the same pace as take-up and conditioning operations on the 30-mile section.

Photographs: Courtesy of H. C. Price Company, Bartlesville, Oklahoma.



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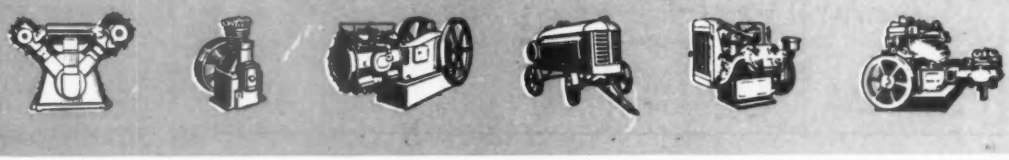


SYNTHESIS OF TOLUENE BY HYDROFORMING and RECOVERY BY AZEOTROPIC DISTILLATION

By **FRED L. HARTLEY,** Union Oil Company of California

PRIOR to the entrance of the United States in World War II, nitration grade toluene for the production of TNT was obtained in relatively small quantities from numerous coke oven operatoins throughout the country. Because this production was a by-product related to the mining and utilization of coal, it was impossible to increase economically and quickly the quantity of toluene from this source. To bridge the gap between a supply of 28,000,000 gal. per year and a demand of over 200,000,000 gal. per year, the hydroforming process[1] developed in peacetime for the desulphurization and octane improvement of motor gasolines was immediately available for the job of producing toluene from selected petroleum fractions. Therefore, at the request of army ordnance the petroleum industry undertook to supply the bulk of the nation's wartime toluene. By late 1942 the terminology of gallons per day per coke oven plant had been changed to the more familiar refinery expression of barrels per day per toluene unit.

*Presented before California Natural Gasoline Association, Los Angeles, October 12, 1945.

[1]Developed and licensed by The M. W. Kellogg Company.

[2]George Lake, June 25, 1945, *AIChE Transactions.*

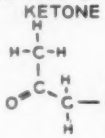
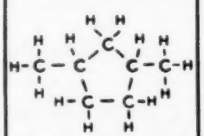
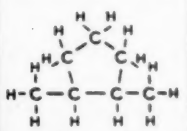
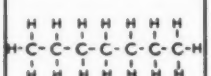
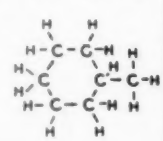
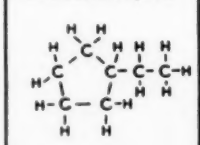
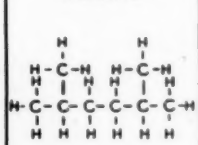
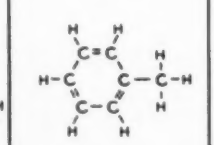
At Union Oil Company's Oleum refinery a hydroforming unit for the treating of motor gasoline was put into initial operation in the Fall of 1941. Concurrent with the design and erection of the commercial hydroformer, the research department of Union Oil Company was investigating azeotropic distillation[2] and in particular its application to the recovery and purification of toluene from hydrocarbon fractions produced by hydroforming. By January, 1942, ground was broken for a plant to recover toluene from hydroformate. By January, 1943, the plant was in operation and shortly thereafter was producing 600 bbl. a day of nitration grade toluene.

● **Feed stock for synthesis of toluene by hydroforming.** Fig. 1 shows the structural formula, boiling point, and gravity of the hydrocarbons associated with toluene synthesis and recovery. Dimethylcyclopentane, methylcyclohexane, and ethylcyclopentane are the 3 chief "synthesis compounds" from which toluene can be synthesized in a hydroformer. Dimethylcyclopentane and ethylcyclopentane are 5-carbon ring naphthenes, which are first isomerized to methylcyclohexane, a 6-carbon ring naphthene, and then dehydrogenated to toluene. Toluene is made up of the 6-carbon benzene ring with one of the hydrogens replaced by a methyl group. Going from the naphthene to the aromatic in the same boiling range, there is a decrease in gravity of between 25 and 40 deg. API. This change in gravity is sometimes used analytically to determine the approximate toluene content of a given sample. Normal heptane and dimethylhexane are 2 typical paraffin hydrocarbons contained in the feed stock along with the previously mentioned reactants. These compounds pass through the hydroformer reactor essentially unchanged and consequently contaminate the raw synthetic toluene hydroformate. To remove these paraffins in the toluene recovery step, the azeotropeformer methyl ethyl ketone-water is used. This compound, an oxygenated derivative of butane, boils at 175°F., considerably below that of the paraffins and toluene in the hydroformate. The constant boiling mixture (164°F.), approximately 90 per cent MEK, 10 per cent H_2O, has the property of loosely combining and lowering the boiling point of the paraffins and naphthenes contained in the hydroformate and at the same time not affecting the aromatic toluene.

All hydrocarbons shown in Fig. 1 except MEK are contained in California crude oil and natural gasoline. Fig. 2 illustrates the volume of DMCP, MCH, ECP, and toluene present in Los Angeles Basin crude. The synthesis hydrocarbons total 1.45 per cent of the crude, and naturally occurring toluene is equal to 0.56 per cent of the crude. Also shown on Fig. 2 are typical analyses of 400 deg. end point Los Angeles Basin straight run gasoline and 9½ lb. Reid vapor pressure Los Angeles Basin natural gasoline. It can be seen that, in order to include both the synthesis compounds and naturally occurring toluene in the feed stock, a fraction containing everything boiling between about 190°F. and 235° F. must be separated from both the straight run and natural gasoline. At Union's Los Angeles refinery this was accomplished by first taking overhead in a crude tower everything boiling to about 235-240°F. and then redistilling this fraction in a 30-plate tower, taking overhead everything boiling below 190-195°F., and thus removing from the bottom a fraction boiling between 190 and 240°F. ASTM, which on a TBP distillation boils between 160 and 280°F. This operation, commonly called heart cutting, was also carried out at Union's

FIG. 1

HYDROCARBONS ASSOCIATED WITH TOLUENE SYNTHESIS & RECOVERY

MEK, $CH_3COC_2H_5$ METHYL-ETHYL KETONE	DMCP, $C_5H_8(CH_3)_2$ 1,3 DIMETHYL-CYCLOPENTANE	DMCP, $C_5H_8(CH_3)_2$ 1,2 DIMETHYL-CYCLOPENTANE	C_7H_{16} n-HEPTANE
			
°A.P.I., 44.3 B.PT., 175°F.	°A.P.I., 58.5 B.PT., 195°F.	°A.P.I., 56.7 B.PT., 197°F.	°A.P.I., 75.4 B.PT., 209°F.
MCH, $C_6H_{11}CH_3$ METHYL CYCLOHEXANE	**ECP, $C_5H_9C_2H_5$ ETHYL CYCLOPENTANE**	**$C_6H_{12}(CH_3)_2$ 2.5 DIMETHYL-HEXANE**	**C_7H_8 TOLUENE**
			
°A.P.I., 52.4 B.PT., 214°F	°A.P.I., 53.1 B.PT., 217°F	°A.P.I., 72.4 B.PT., 229°F	°A.P.I., 31.7 B.PT., 232°F

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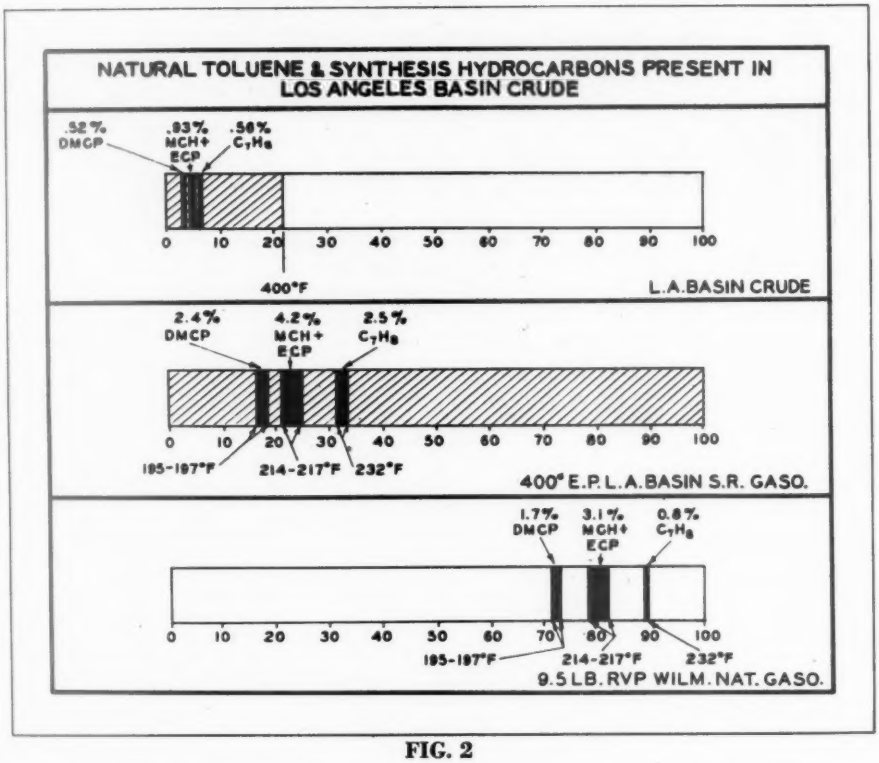


FIG. 2

Oleum refinery in order to make available the maximum volume of hydroformer feed stock obtainable from total crude and natural gasoline runs by the company.

In operating a heart cut tower, it is not possible to set up tower temperature controls accurately by means of simple Engler distillations, because the paraffin-naphthenic type hydrocarbons have in themselves an azeotropic effect to aromatics. The boiling point of toluene is suppressed. By means of true boiling point distillations carried out in high temperature Podbielniak apparatus followed by ultimate hydrocarbon analysis, it is possible to determine ultimate distillation column controls in order that all synthesis compounds and toluene may be recovered and at the same time exclude contamination of fractions boiling above and below the desired fraction.

Referring to Fig. 3, we see a typical true boiling point analysis of the hydroformer feed. This fraction includes essentially 100 per cent of the synthesis compounds and toluene occurring in the crude.

● **The hydroforming synthesis.** Again referring to Fig. 3, we see the change in composition of the hydroformer feed stock after it has been passed through the hydroformer twice. A loss in liquid volume of 40 per cent has occurred. This is because of the reduction in volume caused by the increased gravity of the toluene, large production of gas high in hydrogen content, and coke deposition on the catalyst. Approximately 94 per cent of the synthesis compounds DMCP, MCH, and ECP have disappeared. The toluene content has of course increased at their expense.

The chemical equations for toluene and coke formation are shown in Fig. 4. Dimethylcyclopentane or ethylcyclopentane is first isomerized to methylcyclohexane. The isomerized material, along with the methylcyclohexane occurring naturally in the feed stock, loses one of the hydrogen on each of the 6 carbon atoms making up the naphthenic ring. Upon loss of hydrogen, the unsaturated benzene ring is produced. This reaction results in the production of hydrogen. Some thermal reforming occurs, and consequently in addition to hydrogen the dry gas contains methane, ethane, and propane. Continued dehydrogenation and condensation or polymerization of toluene results in the production of coke. Diagrammatically, this is illustrated by X molecules of toluene condensing to form a very large coke molecule plus additional hydrogen. It is this latter reaction that makes the process for producing toluene by hydroforming so complicated. The coke deposits on the catalyst, deactivating it and necessitating its regeneration.

Synthesis conditions in the commercial hydroformer are as follows:

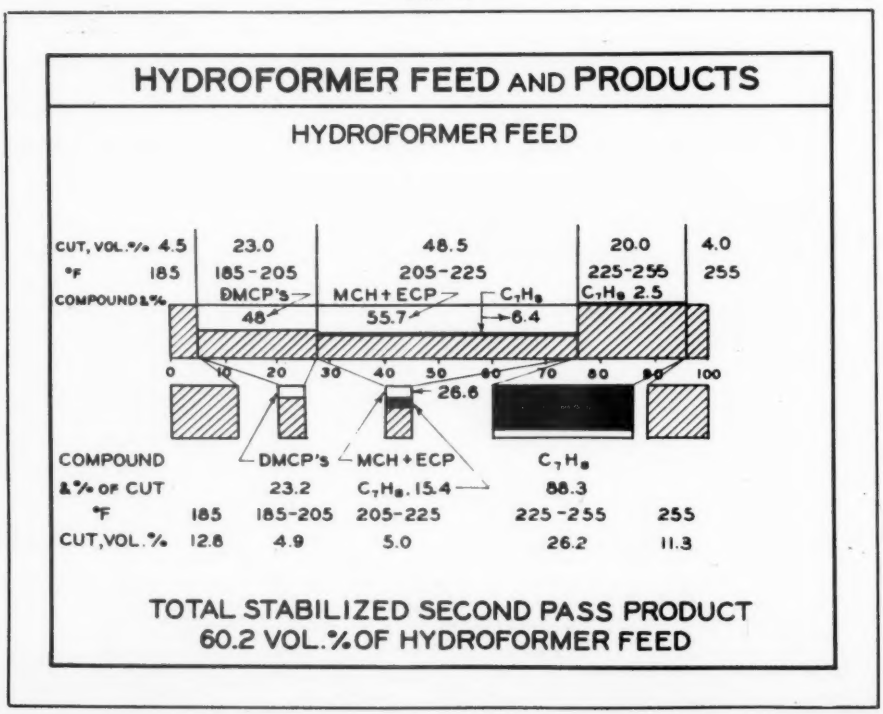
1. Reaction pressure of 150-300 lb.
2. Reactor charge temperature 1000-1070°F.
3. Wet gas recirculation (70 per cent hydrogen) 6000 cu. ft. per bbl. of reactor charge.
4. Dehydrogenation catalyst consisting of 10 per cent molybdenum dioxide on alumina at a space velocity defined as:

$$\frac{\text{Volume of feed/hour/reactor}}{\text{Volume of catalyst in reactor}} = V/V = 0.6.$$

The commercial hydroformer is designed to run up to 9000 bbl. per stream day of charge stock. Because it is necessary to regenerate the catalyst, multiple reactors are employed, and in the case of Union's hydroformer a total of 6 are used.

Fig. 5 is a diagrammatic flow sheet of the hydroformer. The charge stock enters the plant, is stripped at 170 lb. per sq. in. gage with 150 cu. ft. per bbl. of recycle hydrocarbon gas to remove traces of oxygen that otherwise would cause exchanger fouling, redistilled to reduce furnace coke deposition, preheated by exchange with reactor product, then heated and totally vaporized at 1050°F., joined with the recycle gas that has been heated to 1070°F., passed through two reactors in parallel with a time contact of about 15 sec., out of the reactors through heat exchange equipment and into a gas liquid separator. A majority

FIG. 3


HYDROFORMER FEED AND PRODUCTS
HYDROFORMER FEED
CUT, VOL.% 4.5 23.0 48.5 20.0 4.0
°F 185 185-205 205-225 225-255 255
COMPOUND &% DMCP's MCH+ECP C7H8 C7H8 2.5
48 55.7 6.4
0 10 20 30 40 50 60 70 80 90 100
26.6
COMPOUND DMCP's MCH+ECP C7H8
&% OF CUT 23.2 C7H8 15.4 88.3
°F 185 185-205 205-225 225-255 255
CUT, VOL.% 12.8 4.9 5.0 26.2 11.3
TOTAL STABILIZED SECOND PASS PRODUCT
60.2 VOL.% OF HYDROFORMER FEED

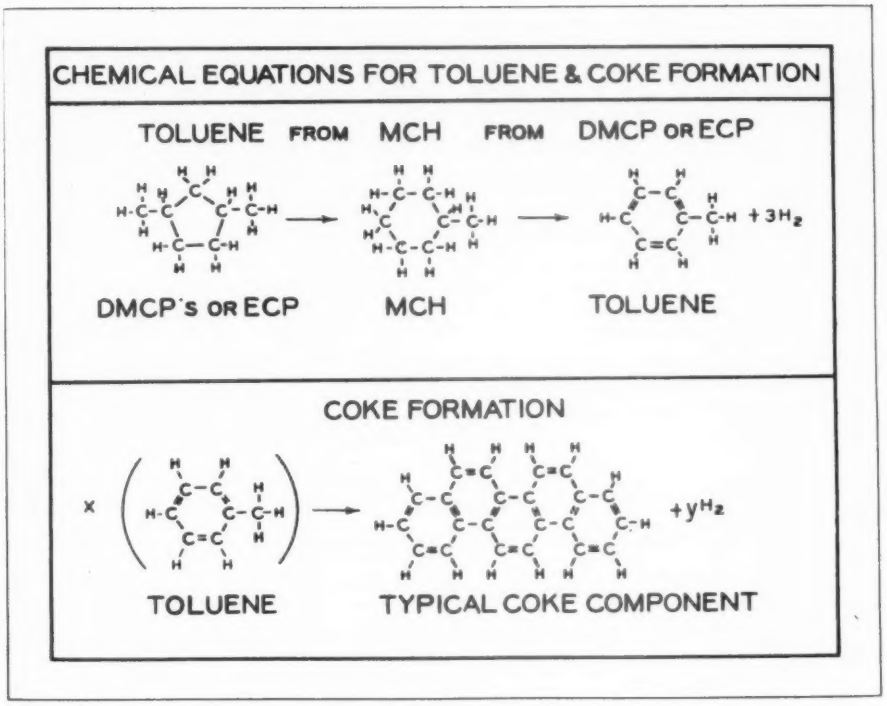


FIG. 4

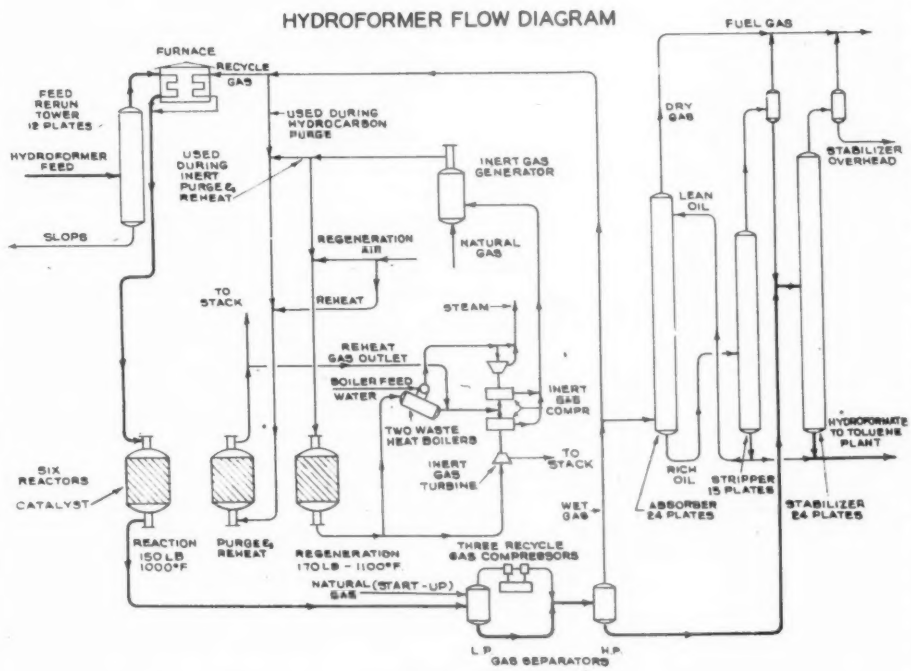


FIG. 5

of the separated wet gas, approximately 48,000,000 ft. a day, is compressed by three 1000-hp. gas engine compressors from 75 to 200 lb. per sq. in. gage and recirculated back through the heat exchange equipment, through the heater, and back into the reactor. The purpose of the wet gas recycle is to increase the hydrogen concentration in the reactor in order to reduce coke deposition and thus maintain catalyst activity. The net gas and liquid production passes into a conventional stabilizing and absorption plant to produce fuel gas, 170 end point gasoline, and hydroformate. The hydroformate, if first pass (that is, first time through the hydroformer), goes to storage. At about the end of two weeks the first pass production is blocked back through the hydroformer, resulting in the production of second pass hydroformate. The reason for the 2-pass operation is to obtain maximum conversion to toluene of the synthesis compounds. In Union's particular hydroformer this cannot be accomplished in one step because the heat requirement for the reaction is so great that a reduction in temperature across the bed of 150°F. is experienced. The first pass material consequently is only about one-half converted. On second passing the conversion is essentially completed. While 2 of the reactors are on reaction, 3 others are being regenerated. The sixth is either being prepared to go on regeneration or back on to reaction.

After the reaction period, the remaining hydrocarbons are swept out by purging with wet gas production. After the hydrocarbon purge step the reactor is purged with inert gas. At the end of 9 min. the reactor has been completely purged of vaporizable hydrocarbons and is ready for regeneration.

Regeneration of the coked catalyst is accomplished by bleeding 190-lb. air into an inert gas, essentially N_2 and CO_2, circulating stream. Two 3000-hp. steam-driven reciprocating compressors supply the air. The inert gas at controlled oxygen content of about 1½ per cent passes downward through the reactors on regeneration; the oxygen combines with the coke to form carbon dioxide and water; the inert gas removes the heat of combustion and in passing through the catalyst bed is raised from an inlet temperature of 700°F. to an outlet of 1100°F.

The hot inert gas circulates through 2 waste heat boilers from which are generated up to 120,000 lb. per hr. of 450-lb. steam and out of which the 700°F. flue gas goes to the suction of 2 identical 3000-hp. circulating blowers operating in parallel. The blowers handle a total of 320,000,000 ft. of gas a day and compress it from 160 to 180 lb. The compressed gas returns to the 3 reactors on regeneration, thus completing the cycle. Make inert gas at 900°F. and 150 lb. per sq. in. gage is used to operate a 3000-hp. inert gas turbine that in turn drives one of the inert gas blowers. The 450-lb. steam production is used to operate a 3000-hp. steam turbine that in turn drives the other 3000-hp. blower. Steam leaves this turbine at 150 lb. and is reused to drive the steam-driven air compressors operating at 26-in. Hg vacuum back pressure.

Upon completion of the catalyst regeneration in any one reactor, hot flue gas from one of the other reactors on regeneration flows up-flow through the regenerated reactor, reheating the catalyst bed from about 700 to 900°F. This is called the reheat step, and upon its completion the reactor is depressured to atmospheric pressure and the inert gas removed by purging with wet gas production. During the purge period the hydrogen in the wet gas reduces the molybdenum from the trioxide MoO_3 to the dioxide MoO_2. The water formed during the reduction is swept out of the reactor. If the purge were conducted at 150 lb. instead of atmospheric pressure, the water would remain on the catalyst and lower its activity. Upon completion of the hydrocarbon purge the reactor is repressured back to 150-lb. reaction pressure and is then ready to go back on reaction.

The above operations constitute a cycle with an elapsed time of 6 hr. To synchronize the cycle an automatic cycle controller is employed. This controller

sends out impulses to electrical relays that in turn actuate electric motors, which in turn operate a total of 52 gate valves. What otherwise would be a batch system is made continuous by means of multiple reactors and the automatic electrical control system.

● **Toluene recovery and purification.** Referring to Fig. 6, the 2-pass hydroformate containing about 38 per cent toluene now goes to the toluene recovery plant. Prior to the azeotropic distillation step, the hydroformate is heart cut to form as narrow a boiling range feed stock as is possible in order to reduce the methyl ethyl ketone-water azeotrope-former requirements. This is accomplished by simple fractional distillation in two 40-plate towers, the overhead from the first being a pre-toluene or benzene fraction, from the second the toluene heart cut, and from the bottom of the second a post-toluene or xylene fraction. The toluene heart cut containing about 65 per cent toluene is fed into the azeotropic tower along with the methyl ethyl ketone-water azeotrope-former. In the azeotropic tower the MEK-water mixture loosely associates with the paraffins and naphthenes and carries them overhead. The toluene, because of its higher boiling point, proceeds down the tower from the feed tray and is removed from the bottom as crude toluene.

FIG. 6

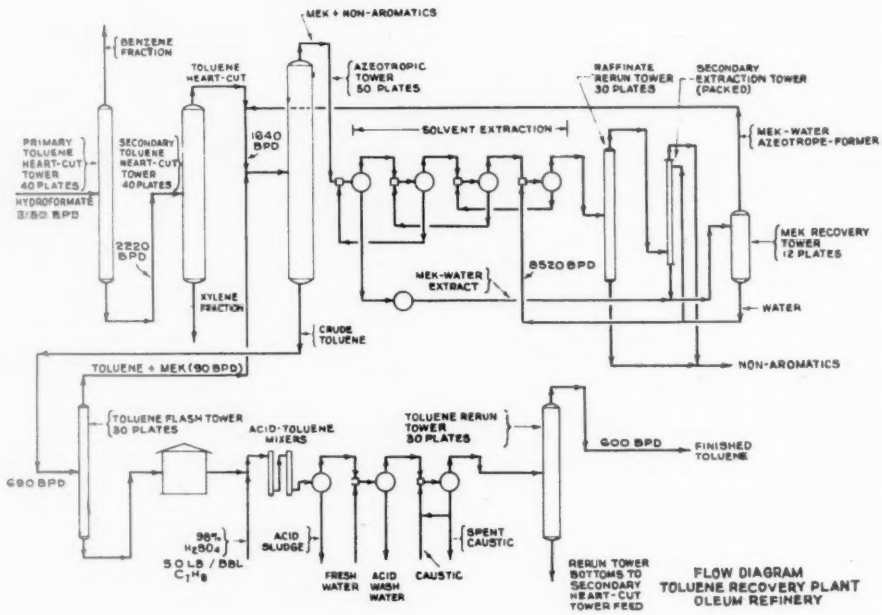
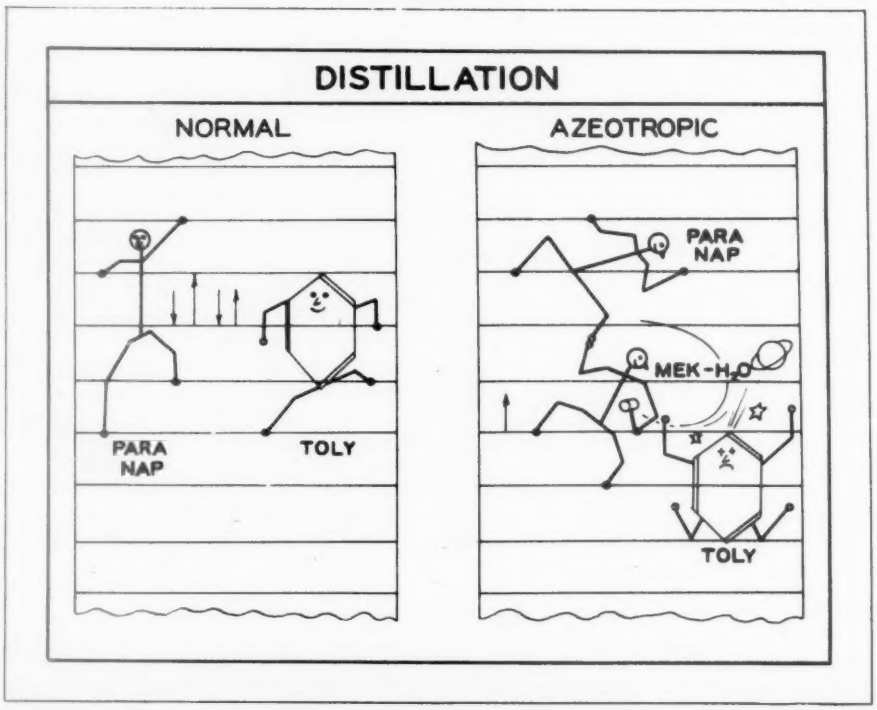


FIG. 7



The crude toluene goes to a toluene flash tower from which overhead goes a small cut of toluene plus MEK, and out the bottom an MEK-free crude toluene. The crude toluene is treated with about 5 lb. per bbl. of 98 per cent sulphuric acid, settled, water washed, and caustic washed to remove very small amounts of olefins to obtain color stability. The acid treated toluene is then redistilled to produce overhead finished nitration grade toluene. As an alternate operation one-pass hydroformate containing 21 per cent toluene is heart cut to give an azeotropic tower feed containing 39 per cent toluene. Paraffins and naphthenes are removed from this dilute charge stock without difficulty by the MEK-H_2O azeotrope-former.

The methyl ethyl ketone plus non-aromatics taken overhead in the azeotrope tower are contacted with 4 to 6 volumes of water counter-currently in 4 stages. The MEK is preferentially extracted by the water from the non-aromatics and separates out as a separate phase. The extract is fed into a 12-plate MEK recovery tower to produce overhead the MEK-water azeotrope-former plus excess water, and MEK-free water out the bottom. The water cycles back to the MEK extractors. The non-aromatic raffinate from the water extraction is fed into a raffinate rerun tower from which leave at the bottom MEK-free non-aromatics and overhead a small fraction of non-aromatics rich in MEK. This fraction is extracted with water in a small packed tower from which are taken overhead additional non-aromatics and from the bottom an MEK-water extract that also goes to the MEK recovery tower.

● **The azeotropic distillation process.** The novel feature of the toluene recovery system is the employment of azeotropic distillation for the separation of two materials of similar boiling point. Referring to Fig. 7, the illustration shows what happens when a mixture of paraffins, naphthenes, and toluene is fed into a normal distillation tower. No separation occurs. By adding the MEK-water azeotrope-former along with the feed, a separation becomes possible. MEK-water azeotrope boiling at 164°F. associates itself with the paraffin and naphthene hydrocarbons boiling between 175 and 250°F. These non-aromatics are carried up the column and are taken overhead at a top temperature of about 166°F. The toluene that does not associate with the azeotrope-former leaves the bottom of the tower essentially free of non-aromatics.

In Fig. 8 the process details of the azeotropic distillation tower operation are given. The column itself is a conventional 50 bubble cap tray distillation tower and operates at a bottom pressure of 5 lb. gage. The heart cut toluene feed containing 627 bbl. of toluene and 1017 bbl. of non-aromatics is joined by about 2090 bbl. a day of the MEK-water azeotrope-former (90-10) and 290 bbl. a day of water recycled from the MEK recovery tower. In addition, 300 bbl. a day of water-MEK (80-20), which separates

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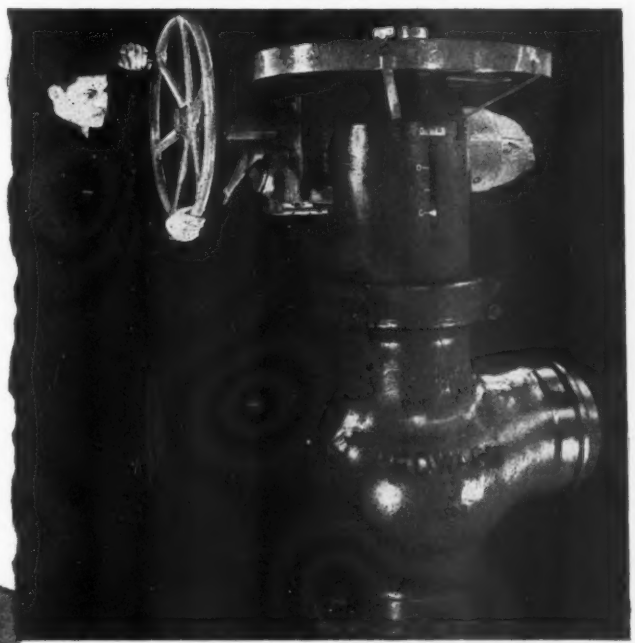

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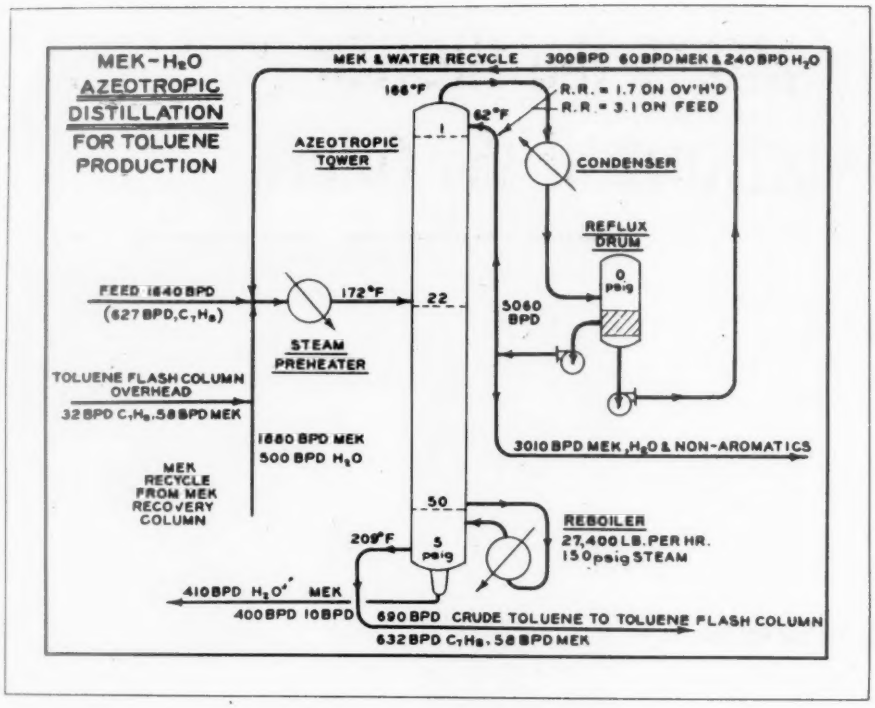
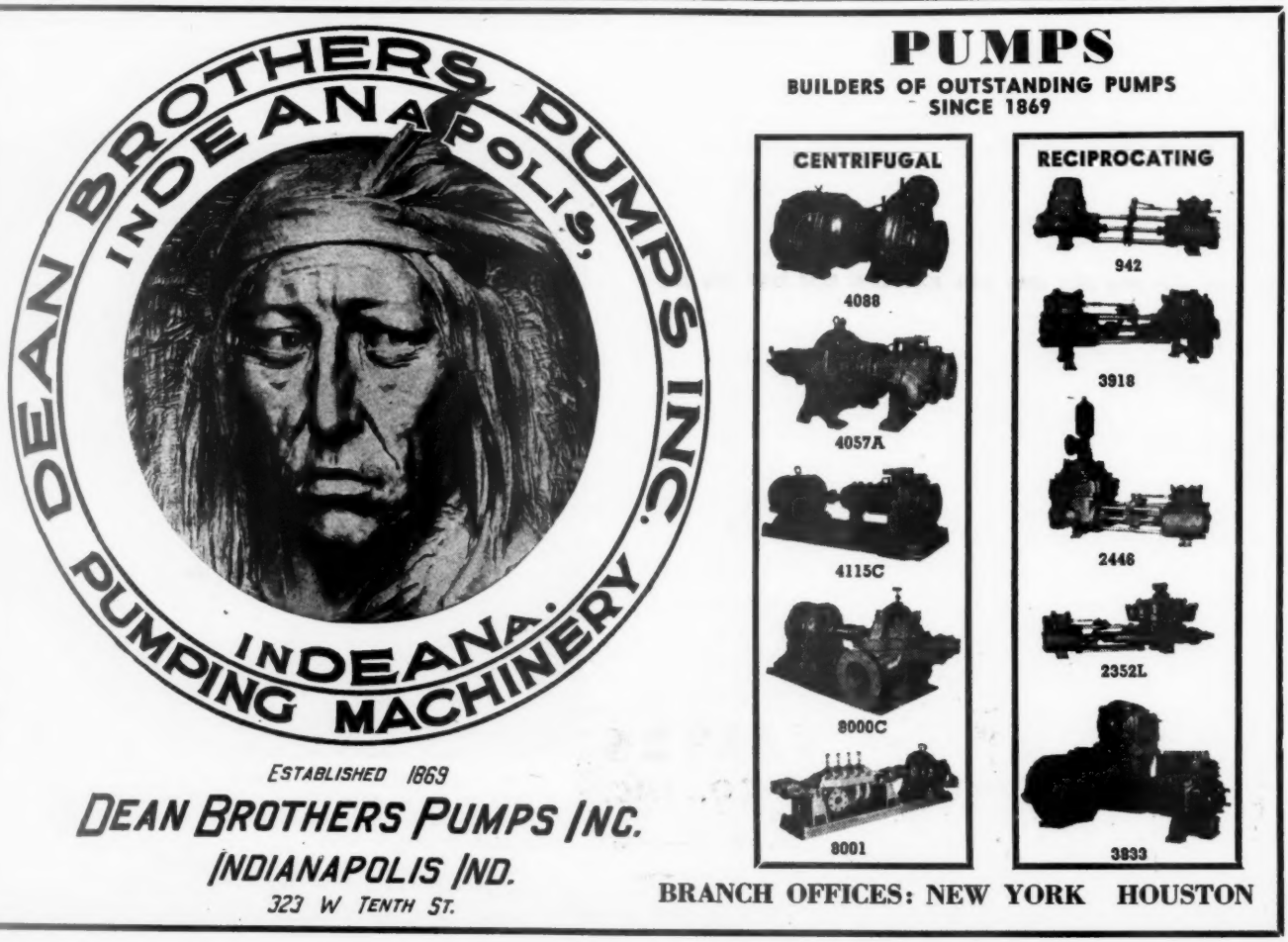


FIG. 8

out in the column reflux drum, are recirculated back to the feed tray, plus a recycle of the overhead from the toluene flash column consisting of 32 bbl. a day toluene and 58 bbl. a day MEK. The ratio of azeotrope-former to non-aromatics is between 2 and 3 to 1, depending on the boiling range and type of non-aromatics present. The combined feed is preheated to 172°F. and enters the column on the 22nd tray. A reflux rate of 5060 bbl. a day corresponding to a cold total reflux to heart cut feed ratio of 3 to 1 is employed to obtain adequate fractionation of the toluene from the non-aromatics and stripping of the non-aromatics from the toluene. Heat is put into the column by means of 2 parallel steam reboilers. Excess water over that required to form the azeotrope with MEK proceeds down the column and is removed as a separate stream from the bottom of the tower. This stream containing a small amount of MEK is recycled back to the MEK recovery tower.

The column is controlled by fixing all possible variables. Feed rate and reflux are on flow control. Heat input to the reboiler is varied by controlling the quantity of steam by means of a temperature controller set to maintain a predetermined reboiler outlet temperature. This temperature is set to permit about 5 per cent MEK to remain in the toluene product. At this MEK concentration complete removal of non-aromatics from the toluene is assured.

In all respects the column operates like a normal distillation tower. Fig. 9 shows the azeotrope column temperature gradient and the analyses of the material on each tray of the column. From these plots we note that the toluene concentration decreases very rapidly in the upper 10 trays of the rectifying section and that the bottom 15 trays of the stripping section are required to obtain complete elimination of the non-aromatics. The MEK concentration remains essentially constant at 70 per cent on the top 30 trays and then decreases in the lower



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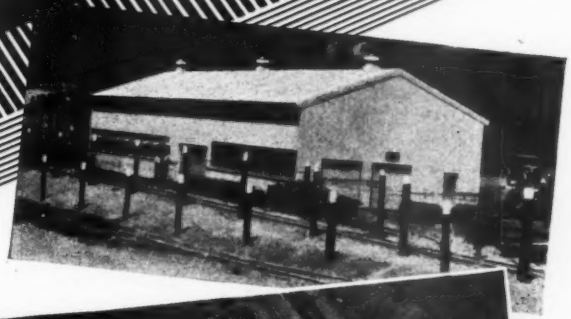

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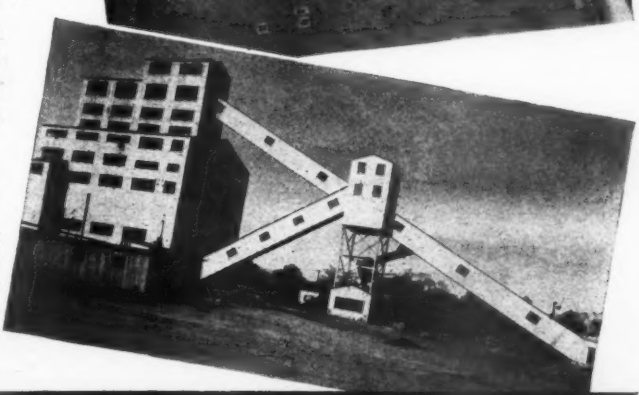

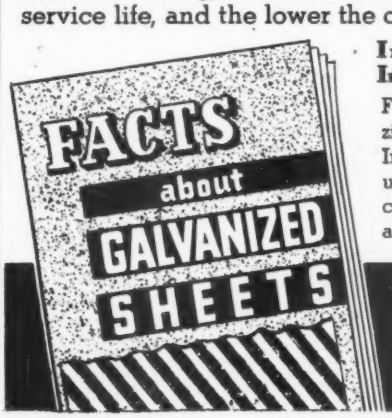

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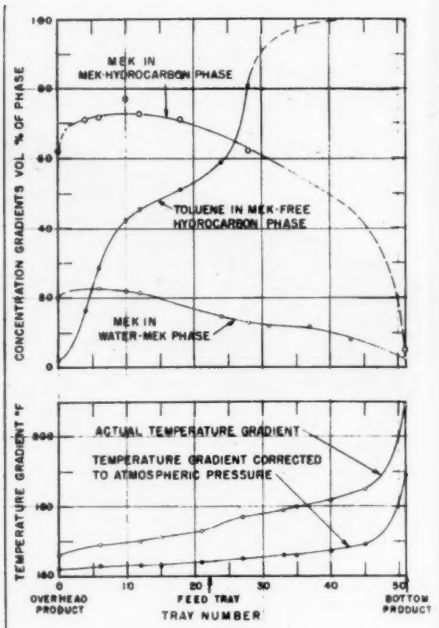


FIG. 9

20 decks to about 5 per cent in the toluene bottoms. Two liquid phases exist on the trays throughout the column, the MEK-water-hydrocarbon phase and the water-MEK phase. Sufficient agitation occurs on the trays so that the normal distillation tray fractionation efficiencies apply.

When the charge stock contains 40 per cent or more aromatics, azeotropic distillation is usually less costly than extractive distillation. An example of this somewhat similar process is the separation of toluene from non-aromatics using phenol as the extractive distillation agent. The chief difference between the two processes is that in azeotroping a majority of the agent goes overhead with the non-aromatics and in extractive distillation a majority of the agent goes out the bottom with the aromatics.

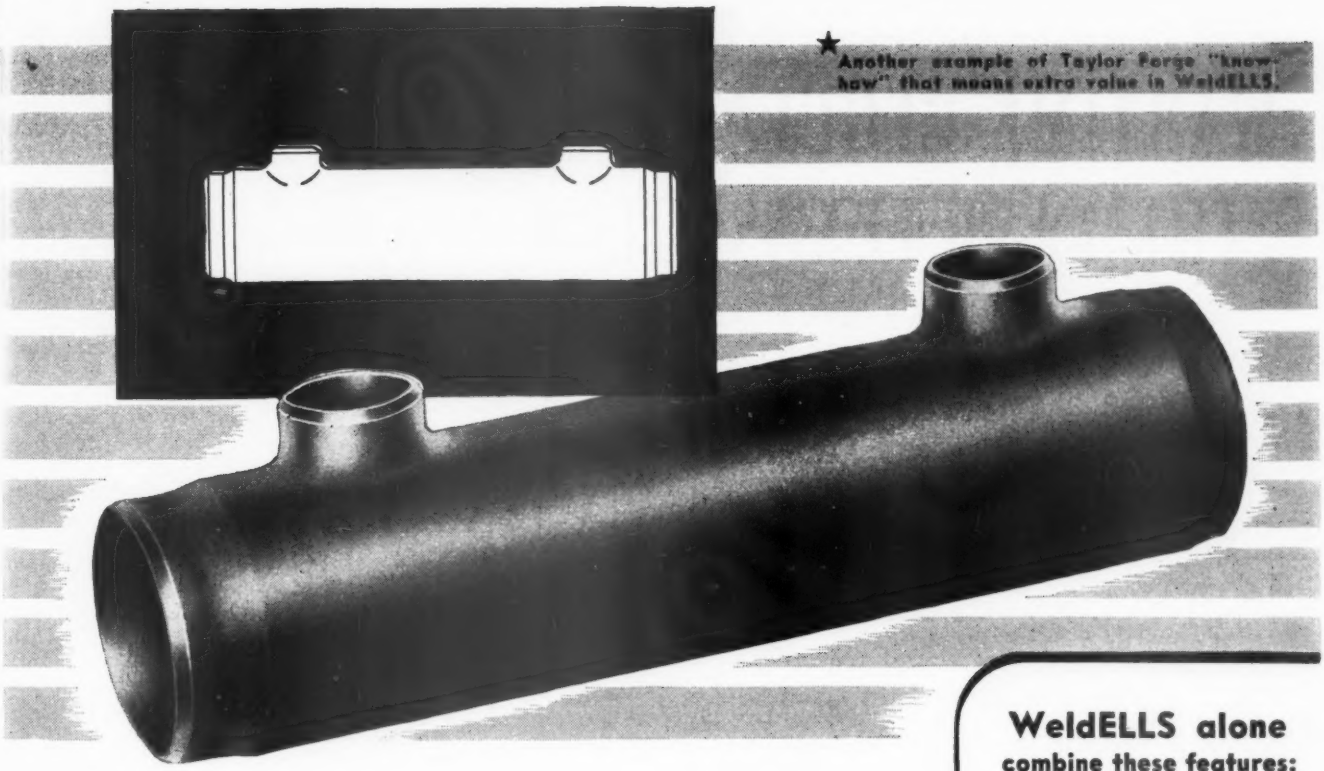
● **Uses of azeotropic distillation.** The field of application of the azeotropic distillation process should greatly increase as the petroleum and chemical industries increase their production of more and more essentially pure compounds. Certainly the production of aromatics by azeotropic or extractive distillation will continue. For separating toluene and xylene from non-aromatics, MEK-H_2O azeotropic former can be employed. For separating toluene from non-aromatics methanol can also be used. Acetone can be used as the azeotropic agent for separating benzene from non-aromatics.

● **Acknowledgment.** The writer expresses his appreciation to all those giving assistance and in particular to George Fekula and Austin McCreery.

★ ★ ★

New map released

A new oil and gas map of Illinois is ready for release January 1, 1945, the first one to be published by that state since wartime censorship began. The map shows location of oil and gas fields, refineries, natural gasoline plants, etc.



★ Another example of Taylor Forge "know-how" that means extra value in WeldELLS.

TEE FOR TWO.....

Taylor Forge arrangement—

★ *Of course two tees with a nipple welded between them could be made to provide an assembly with the same dimensions as this special "tandem outlet tee." However, a rigid set of conditions demanded this seamless one-piece fitting. From there on it was the old familiar story: "This is a tough one—one for Taylor Forge."*

YES, you've heard the story before: A tough one is one for Taylor Forge! It's really no wonder so many of the people who come to Taylor Forge for the unusual, and often very difficult jobs, are equally careful to see that their needs for standard welding fittings are always supplied by Taylor Forge.

They *should* be equally careful, because the very same factors that have built the Taylor reputation for licking the tough ones, provide many extra values that are found only in WeldELLS and other Taylor Forge fittings for pipe welding.

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In fact, you will find Taylor Forge know-how reflected in every one of the features listed opposite. Check the list and we believe you will agree that

WeldELLS alone combine these features:

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- **Wall thickness never less than specification minimum**—assures full strength and long life.
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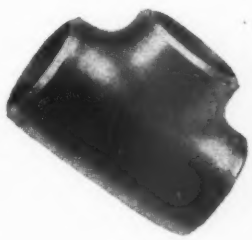

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WARTIME REGULATION OF THE EAST TEXAS FIELD

By **H. J. GRUY**

EXCLUSIVE

THE outstanding performance of the giant East Texas Field was a conspicuous asset to our war effort. Situated at the southwestern terminus of the War Emergency Pipelines and producing a desirable quality of sweet crude, the field supplied a large portion of the oil for the northeastern refineries. It should be remembered, however, that production of the field at the rate required to meet the wartime demands was not brought about solely by virtue of the natural characteristics of the reservoir, but was accomplished through the wise policies of the Railroad Commission of Texas and the cooperation of the 722 operators in the field.

H. J. Gruy

In achieving a sustained high rate of production without causing irreparable damage to the reservoir, numerous precedent-setting rules, regulations, and practices were required. The course was uncharted and the size of the field together with the diversity of ownership made the job seem impossible and would have discouraged a less determined group.

Reference to the curves on Fig. 1 indicates decline in reservoir pressure of approximately 25 lb. per sq. in. during the year of 1941. If field production was to be maintained and the installation of thousands of pumpings units avoided, this decline would have to be checked. As the pressure of the field is a direct function of the withdrawal rate, the return of water to the producing sand or the curtailment of water production was necessary. The Railroad Commission took steps to do both.

Although the need was obvious, a method of accomplishing the desired results without damaging the smaller operators was by no means so clear. Approximately 500 operators in the field had only one lease, and 300 of these had less than 4 producing wells. If the Commission had ordered all water producing wells closed in, many of these operators would have been put out of business and the oil that underlaid their properties would have been lost to them through up-structure migration. An order requiring all the water to be injected into the reservoir was equally impossible in that these small operators could neither afford nor get the material necessary to drill and equip salt water injection wells.

As early as March, 1940, the Commission encouraged salt water injection. Its order No. 6-1456, effective March 29 of that year, provided that any oil producing well that was converted to a salt water disposal well could retain its allowable to be produced by the remaining wells on the same lease.

The Railroad Commission's order No. 6-3142, effective January 1, 1942, provided for a bonus allowable of 1 bbl. of oil for each 50 bbl. of salt water injected into the producing sand. This allowable was earned if all the water produced on the lease was returned to the reservoir. The bonus was to be produced on the lease from which the water was taken, and it was limited to 8 bbl. of oil daily for each water producing well. The wells assigned to produce the bonus oil were limited to 6 bbl. of extra allowable daily.

This order was amended by order No. 6-3437, effective February 20, 1942, so that an operator injecting water was allowed to transfer the bonus allowable to any lease owned by him. This order also provided that, if water was injected through the facilities of a salt water company, the bonus could be transferred to other operators or to the disposal company. In the event that the bonus was transferred to another lease it could not be assigned to a well producing in excess of 25 per cent water.

Bonus oil earned by leases producing water to be injected was transferred to other properties and leases without payment of double royalty in that the bonus is granted to the operator to repay him for expense incurred in having the water returned to the sand. The lease from which the water was produced has no claim to the bonus.

This arrangement of letting the field pay for salt water injection out of the field's reserves is responsible for the success of the salt water injection program. Without it many leases would have been unable to pay the cost of salt water disposal and the East Texas Salt Water Disposal Company probably would not have been formed. Operators consider this system a fair one in that every well in the field is influenced by salt water injection.

The Railroad Commission of Texas also took effective steps to curtail water production. The first was order No. 6-3456, effective February 25, 1942 which permitted wells producing in excess of 100 bbl. of water daily to be shut in with their allowables transferred to other wells on the same lease. Under this order the shut in wells have to be retested every 6 months to establish their allowable for the next period.

The East Texas field is drilled to an average density of 1 well to 5 acres, and in some areas to densities as great as 0.1 acre per well. As a result of equipment shortages federal regulations did not permit installation of pumping equipment to more than 1 well on 10 acres. Under Field Rule No. 23 each well is required to produce its own allowable. Many operators were faced with serious losses of allowable because of inability to equip their wells for pumping under the PAW ruling. The Railroad Commission of Texas came to the aid of these operators with its order No. 20-4189, effective November 17, 1942. This order provides for exceptions to Rule No. 23 for wells that cannot be equipped under federal restrictions, and permits the closing in of these wells when natural flow ceases and the production of their allowable from other wells on the same lease. Exceptions to Rule No. 23 are granted only after a hearing at which the offset operators and other interested parties may voice their opinions.

To restrict water production further and to encourage return of water to the reservoir, order No. 20-4195 was made effective January 10, 1943. This was the first water-oil ratio order. Gas-oil ratio limits have been enforced for a number of years, but no previous order had restricted the amount of water that a well may produce. The order provided for a limitation of oil to that amount produced with a volume of water equal to ten times the well's normal oil allowable. There was a great deal of opposition to this order by operators of wells producing large volumes of water. These operators contended that the order was in conflict with the marginal well law. In the case styled Konowa Operating Company, et al, vs. Railroad Commission of Texas the courts upheld the Railroad Commission's authority to write an order of this type. The order provides for the water-oil ratio to be calculated on the basis of net water production after deducting the injected water from the total water produced. This provision eliminates water-oil ratio penalties on wells that have all their water production returned to the sand. This is another incentive for water injection.

On January 15, 1943, the previous salt water bonus orders were liberalized by Railroad Commission Order No. 6-4351,

*H. J. Gruy, a graduate of Texas A. & M. College, is now associated with the consulting firm of DeGolyer and MacNaughton. He formerly served as an engineer for the Standard Oil Company of Texas and Shell Oil Company, Incorporated. While with Shell he worked as an exploration engineer in a number of districts in the Texas Gulf Coast, Southwest Texas, Louisiana Gulf Coast, Arkansas, North Louisiana, and the East Texas area.

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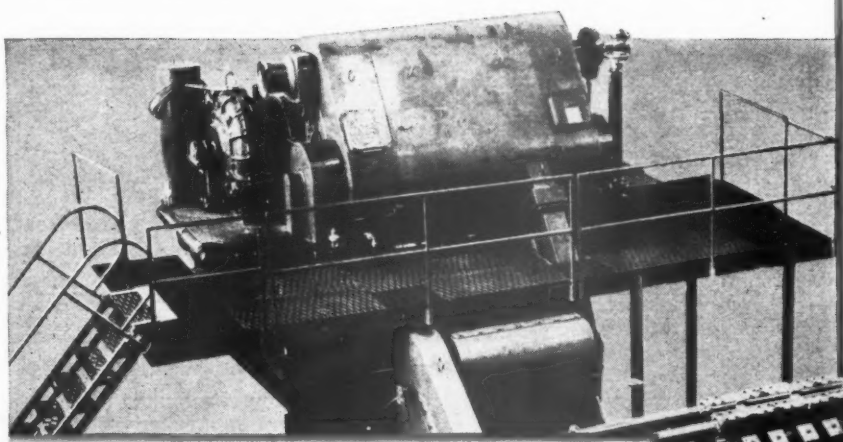

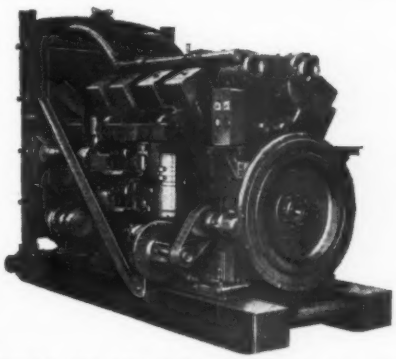

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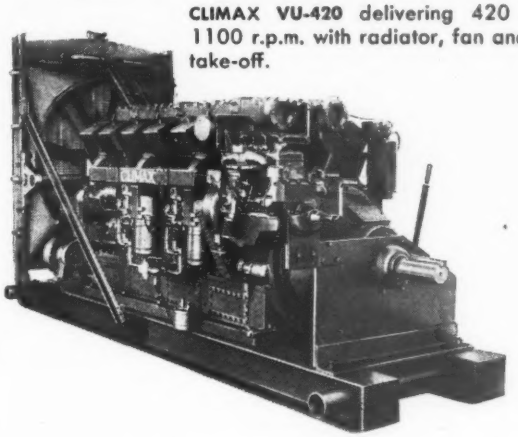

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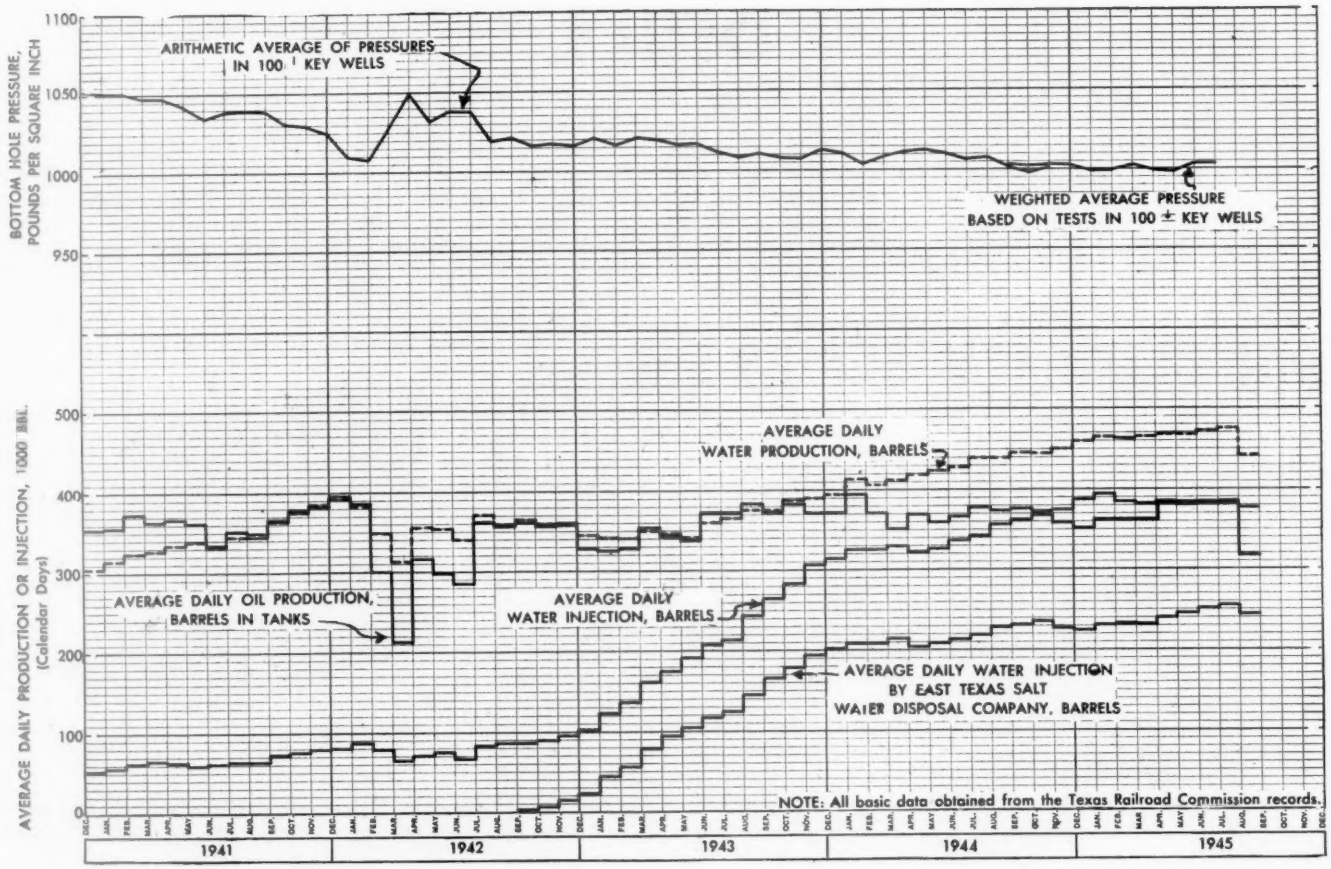

BOTTOM HOLE PRESSURE, POUNDS PER SQUARE INCH
AVERAGE DAILY PRODUCTION OR INJECTION, 1000 BBL. (Calendar Days)
ARITHMETIC AVERAGE OF PRESSURES IN 100 ± KEY WELLS
WEIGHTED AVERAGE PRESSURE BASED ON TESTS IN 100 ± KEY WELLS
AVERAGE DAILY WATER PRODUCTION, BARRELS
AVERAGE DAILY OIL PRODUCTION, BARRELS IN TANKS
AVERAGE DAILY WATER INJECTION, BARRELS
AVERAGE DAILY WATER INJECTION BY EAST TEXAS SALT WATER DISPOSAL COMPANY, BARRELS
NOTE: All basic data obtained from the Texas Railroad Commission records.
1941
1942
1943
1944
1945

FIG. 1

TABLE 1

Railroad Commission bottom hole pressure, East Texas field, lb. per sq. in., gage. (See Fig. 1)

First of month	1941	1942	1943	1944		1945	
	Arithmetical average	Arithmetical average	Arithmetical average	Arithmetical average	Weighted average	Arithmetical average	Weighted average
January	1051.73	1025.58	1015.71	1012.44		1001 25	1002.58
February	1050.93	1009.73	1020.55	1010.20		994.84	999.40
March	1050.45	1007.87	1016.14	1003.47		998.19	999.70
April	1047.22	1027.12	1020.44	1008.50			1002.02
May	1047.64	1049.75	1019.16	1011.26			999.75
June	1042.29	1031.51	1016.21	1012.29			998.27
July	1034.63	1038.49	1016.98	1009.97			1003.79
August	1038.48	1037.71	1012.22	1006.24			
September	1038.90	1019.42	1008.46	1007.88			
October	1038.56	1020.71	1010.60	1001.61	1003.90		
November	1030.46	1016.24	1007.62	998.33	1002.28		
December	1029.46	1019.12	1007.41	1001.63	1002.90		

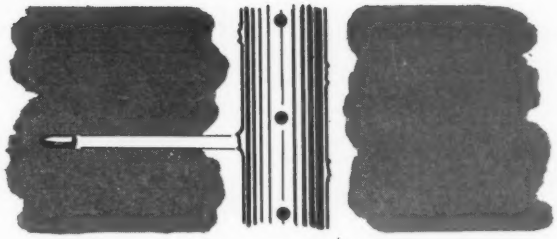
allowing bonus oil to be transferred to any operator or lease in the field regardless of whether the water was injected by the operator or through the facilities of a salt water disposal company. This order benefited those operators who had gone to the expense of installing salt water disposal facilities of their own. The previous order allowed bonus oil to be produced from a lease other than the water producing lease only if the water was injected by a salt water disposal company.

Many wells were closed in as water wells producing in excess of 100 bbl. of water daily; however, operators were unable to make full use of the released equipment because the pumping units and engines had to be set back on the wells for semi-annual tests. Often high capacity wells producing only small volumes of water had to be taken off production to permit testing of these closed in wells. An operator with 10 wells on a 50-acre lease could only equip 5 wells to pump under Order M-68 and PAO-11. Naturally he wanted the pumps on the 5 best wells and he wanted to make the allowable of the other wells by transfers of allowable as exceptions to Rule No. 23 or as large volume water wells. To bring a portable unit on the lease to test the shut in wells in order to continue their allowables was a violation of Order M-68. A committee of engineers studied the results of previous tests and established an average rate of production decline for wells producing in excess of 100 bbl. of salt water daily. Railroad Commission Order No. 6-4571, effective March 16, 1943, gave operators the option of declining the allowable of closed in water wells according to this curve to avoid the necessity of semi-annual tests. Under this order a well's allowable is reduced at quarterly intervals to an amount equal to 81.325 per cent of the allowable during the previous quarter. The allowable is discontinued after it reaches 4 bbl. daily. The well may be equipped and produced for whatever it will make after going off the curve, if equipment is available and the operator desires to install it. The order provides that the well may not be closed in and the allowable transferred under any other order after having been on "the curve." The curve option has been very popular and has proved so accurate that many operators plug wells that are on "the curve" without bothering to test them to make sure they are depleted. A well that is shut in under the curve option may be

TABLE 2

East Texas field, salt water injection, August daily bbl. (see Fig. 1).

	1941	1942	1943	1944	1945
January	51,878	79,808	102,059	312,801	352,769
February	56,265	86,740	124,754	325,522	363,046
March	60,923	79,495	137,064	325,648	363,060
April	64,956	64,248	160,828	330,499	362,978
May	63,043	70,793	176,727	321,806	383,921
June	58,977	75,716	190,922	328,375	383,637
July	60,682	68,002	208,555	337,253	382,118
August	64,006	83,874	214,946	341,831	385,829
September	64,097	87,588	243,542	358,452	376,695
October	72,476	87,007	265,979	361,936	
November	75,898	88,932	283,148	368,981	
December	79,005	95,319	306,810	358,725	



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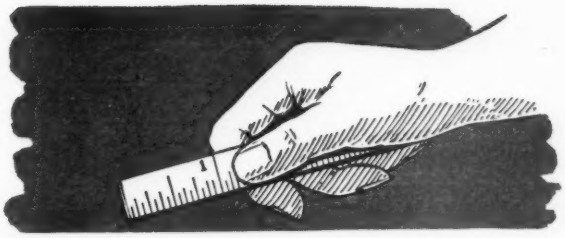

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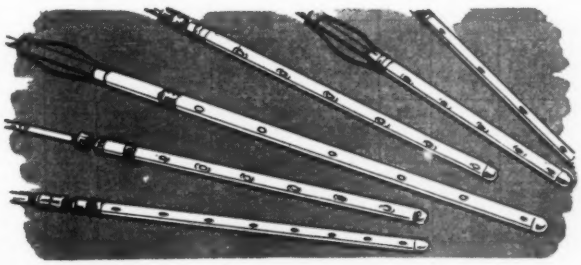

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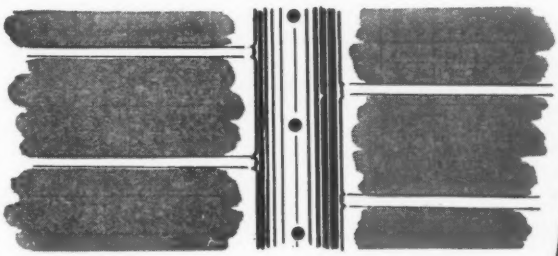

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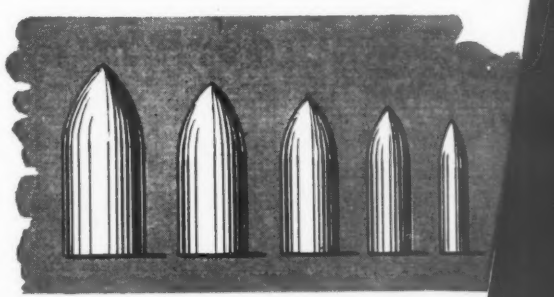

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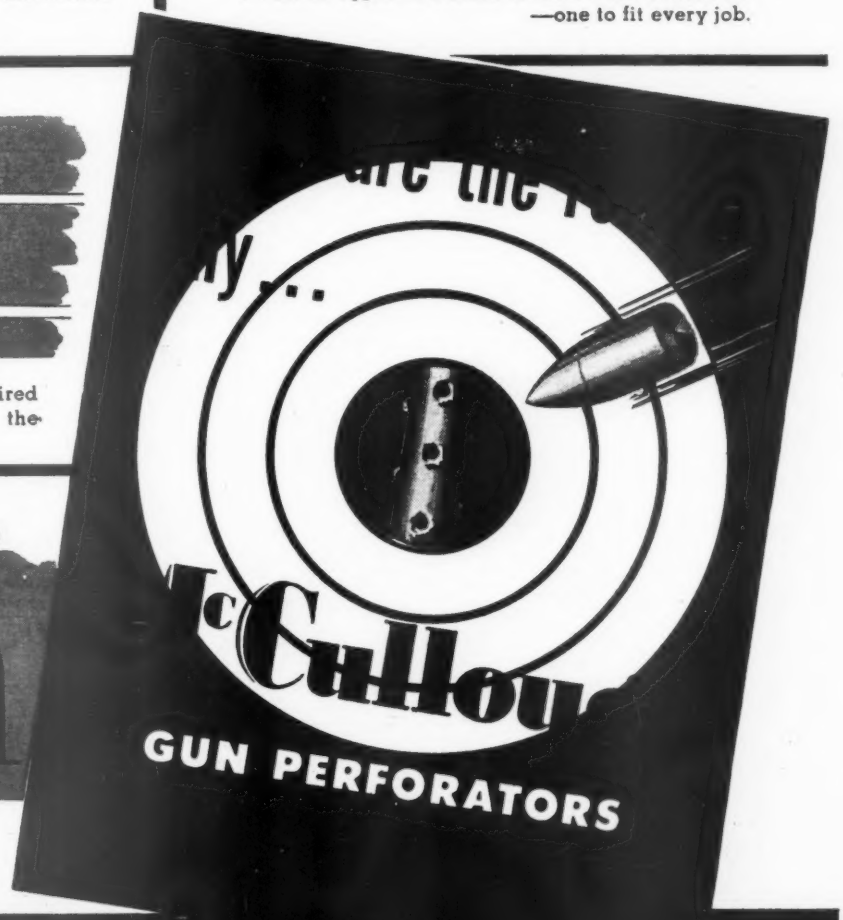

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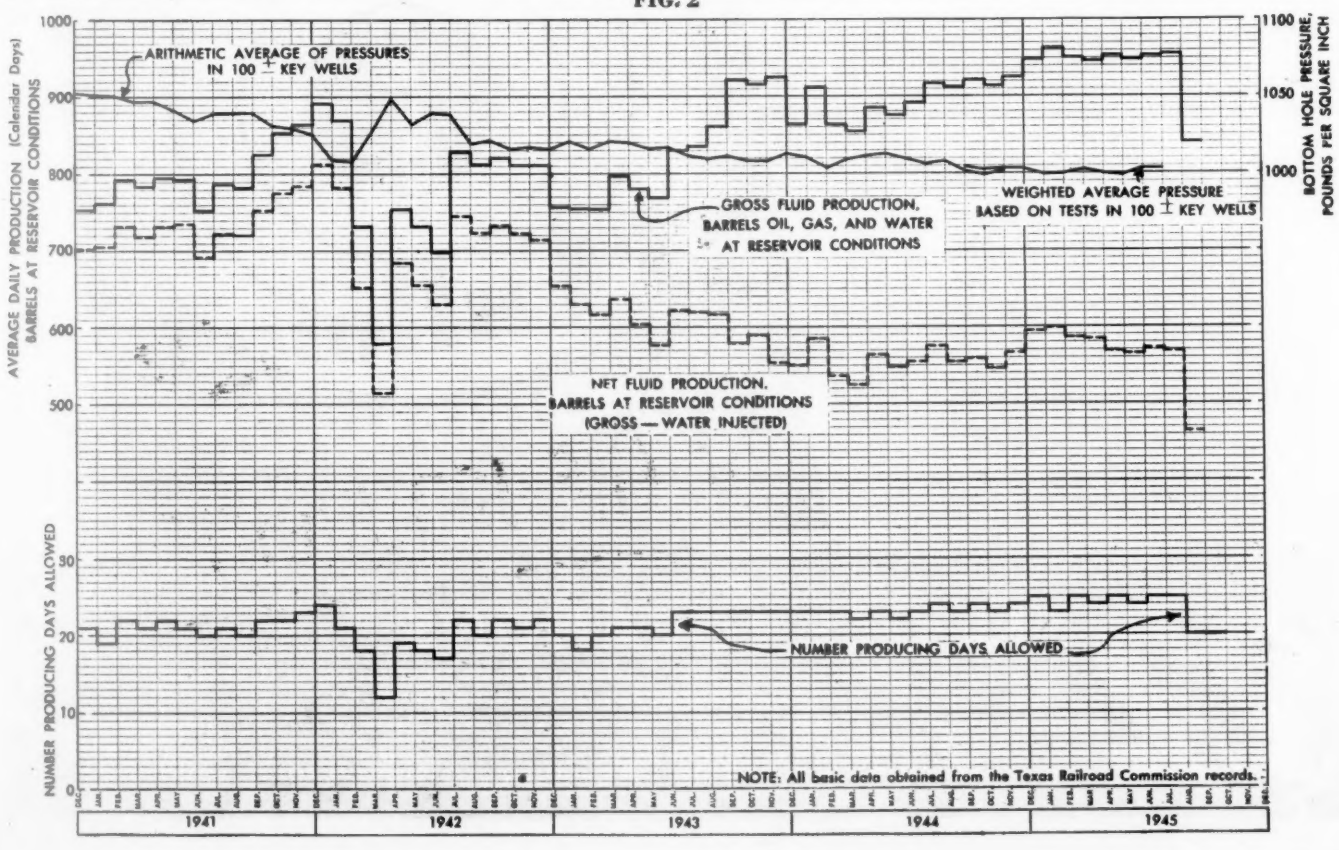
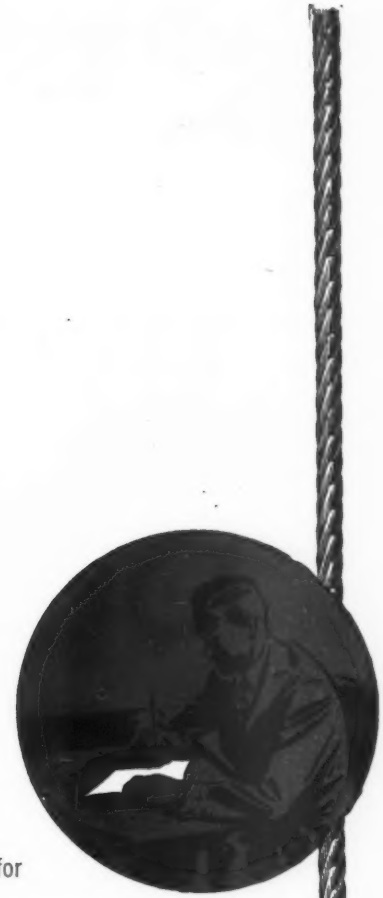
TABLE 3. East Texas Field—Producing days and shutdown days (see Fig. 2).

	1937		1938		1939		1940		1941		1942		1943		1944	1945
	Down	Prod.	Down	Prod.	Down	Prod.	Down	Prod.	Down	Prod.	Down	Prod.	Down	Prod.	Prod.	Prod
January.....		31	23-30	29	1, 7, 8, 14, 15, 21, 22, 28	23	3, 6, 7, 10, 13, 14, 17, 20, 21, 24, 27, 28, 31	18	1, 4, 5, 8, 11, 12, 18, 19, 25, 26	21	4, 11, 15, 18, 29, 30, 31	24	11 days	20	23	25
February.....		28	6, 13, 20, 27	24	4, 5, 11, 12, 18, 19, 25, 26	20	3, 4, 7, 10, 11, 14, 17, 18, 21, 24, 25, 28	16	1, 2, 8, 9, 15, 16, 22, 23, 28	19	4, 8, 14, 15, 21, 22, 28	21	10 days	18	23	23
March.....		31	6, 13, 20, 27	27	4, 5, 11, 12, 18, 18, 19, 25, 26	23	3, 6, 9, 10, 13, 16, 17, 20, 23, 24, 27, 30, 31	18	2, 8, 9, 15, 16, 22, 23, 30, 31	22	1, 7, 8, 11, 12, 14, 15, 18, 21, 22, 25, 30, 31	18	11 days	20	23	25
April.....		30	3, 10, 17, 24	26	2, 9, 16, 23, 30	25	1, 6, 9, 10, 13, 16, 17, 20, 23, 24, 27, 30	18	5, 6, 12, 13, 19, 20, 26, 27, 30	21	3, 4, 5, 6, 10, 11, 12, 13, 17, 18, 19, 20, 24, 25, 26, 27, 29, 30	12	9 days	21	22	24
May.....		31	1, 8, 14, 15, 21, 22, 28, 29	23	6, 7, 13, 14, 21, 28	25	1, 4, 5, 8, 11, 12, 15, 18, 19, 22, 25, 26, 29, 31	17	3, 4, 10, 11, 17, 18, 24, 25, 31	22	2, 3, 4, 8, 9, 10, 11, 14, 15, 16, 17, 18	19	10 days	21	23	25
June.....		30	4, 5, 11, 12, 18, 19, 25, 26	22	3, 4, 10, 11, 17, 18, 24, 25	22	1, 2, 5, 8, 9, 12, 15, 16, 19, 22, 23, 26, 29, 30	16	1, 7, 8, 14, 15, 21, 22, 28, 30	21	1, 6, 7, 13, 14, 20, 21, 23, 27, 28, 29, 30	18	10 days	20	22	24
July.....		31	3, 10, 17, 24, 31	26	1, 2, 8, 9, 15, 16, 22, 23	23	4, 7, 10, 14, 18, 21, 28	24	4, 5, 6, 12, 13, 16, 19, 20, 26, 27, 31	20	4, 5, 6, 11, 12, 13, 18, 19, 20, 25, 26, 29, 30, 31	17	8 days	23	23	25
August.....		31	7, 14, 21, 28	27	5, 6, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29	12	1, 4, 8, 11, 15, 18, 22, 25, 30	22	2, 3, 9, 10, 16, 17, 23, 24, 30, 31	21	8, 9, 15, 16, 22, 23, 29, 30, 31	22	8 days	23	24	25
September.....		30	3, 4, 10, 11, 17, 18, 24, 25	22	2, 3, 9, 10, 12, 13, 16, 17, 23, 24, 30	19	1, 2, 8, 14, 15, 21, 22, 29, 30	21	1, 6, 7, 13, 14, 20, 21, 27, 28, 30	20	5, 6, 12, 13, 19, 20, 26, 27, 30	20	7 days	23	23	20
October.....		31	1, 2, 8, 9, 15, 16, 22, 23	23	1, 2, 7, 8, 14, 15, 21, 22, 27, 28, 29	20	5, 6, 12, 13, 19, 20, 26, 27, 31	22	4, 5, 11, 12, 18, 19, 25, 26, 31	22	3, 4, 10, 11, 17, 18, 24, 25, 31	22	8 days	23	24	20
November.....	21-28	28	5, 6, 12, 13, 19, 20, 26, 27	22	1, 4, 5, 11, 12, 15, 18, 19, 25, 26, 30	19	2, 3, 9, 10, 16, 17, 24, 28, 30	21	2, 8, 9, 11, 16, 23, 27, 30	22	*	21	7 days	23	23	
December.....	5-12	29	3, 4, 10, 11, 18, 24, 25, 31	23	1, 2, 3, 9, 10, 16, 17, 23, 24, 25, 30, 31	19	1, 7, 8, 14, 15, 21, 23, 24, 25, 31	21	6, 7, 13, 14, 21, 25, 28, 31	23		22	8 days	23	24	
Total.....		361		294		250		234		254		236		258		

*After October, 1942, the Railroad Commission of Texas fixed the number of down days without specifying the exact dates.

FIG. 2





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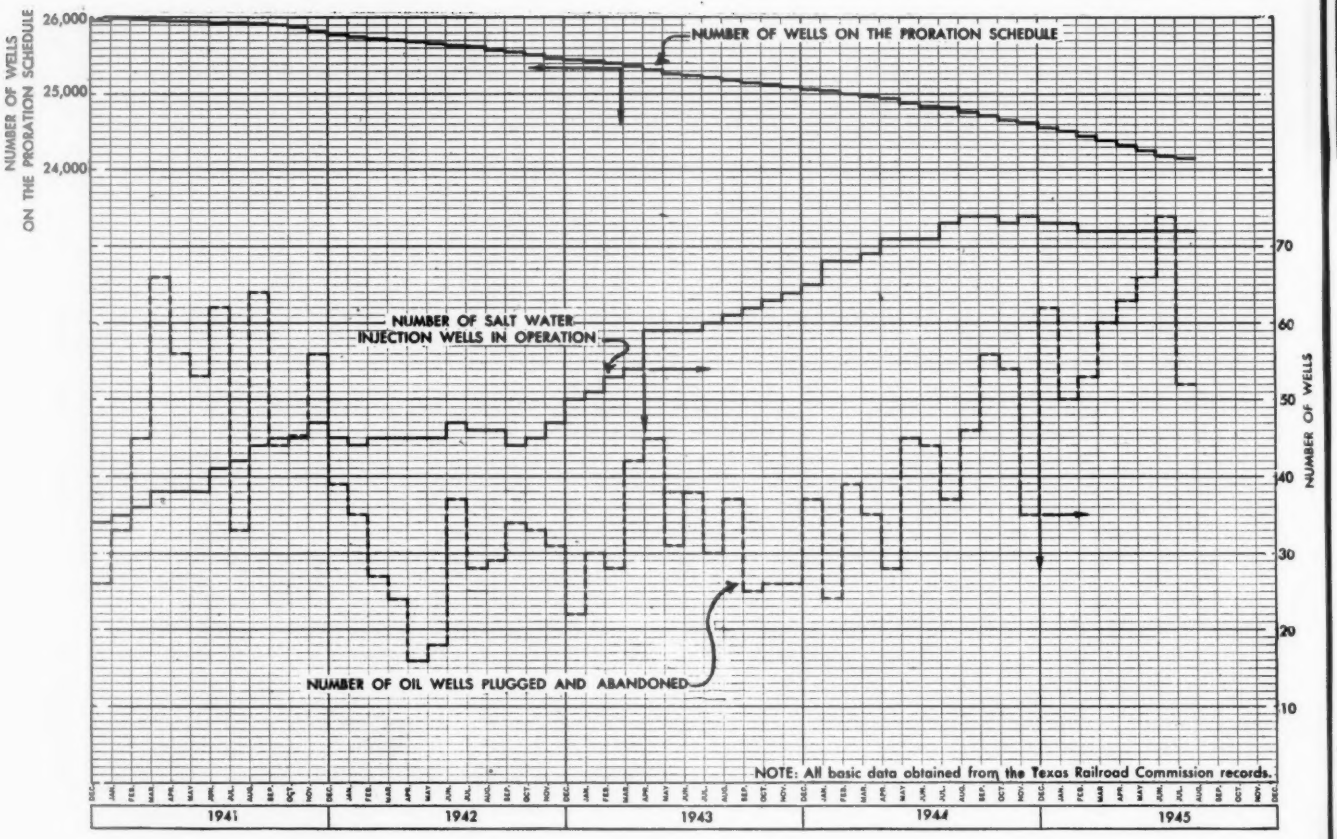

FIG. 3

TABLE 4
Number of salt water injection wells operating (see Fig. 3).

	1941	1942	1943	1944	1945
January	34	45	50	65	73
February	35	44	51	68	73
March	36	45	53	68	72
April	38	45	54	69	72
May	38	45	59	71	72
June	38	45	59	71	72
July	41	47	59	71	72
August	42	46	60	73	72
September	44	46	61	74	
October	45	44	62	74	
November	45	45	63	73	
December	47	47	64	74	

plugged and abandoned without discontinuing its allowable.

In May, 1943, operators began having difficulties under the provision of the bonus oil orders that required all water production on the lease to be injected. Operating problems are such that it is difficult and often impossible to have all the water injected during the month it is produced. In the event that the water level in a lease salt water storage pit rose a few inches during the month, it was obvious that all the water production had not been injected and the operator producing the bonus was in danger of having his production barred from movement in interstate commerce. To avoid this difficulty the Railroad Commission issued its Order No. 6-4877, effective May 31, 1943, providing that bonus oil is earned on salt water injected even if all salt water produced on the lease is not injected.

On July 1, 1943, the water-oil ratio order was revised by reducing the allowed ratio to 5 bbl. of water for each barrel of oil. The order that made this revision is No. 20-4959.

Many small stripper leases that produce considerable volumes of water are not attractive for salt water disposal systems because of their short life expectancy. In other words the leases may be abandoned before salt water disposal charges will repay the cost of laying a pipe line to collect the water. Some leases of this type were so severely restricted by the 5-to-1 water-oil ratio order that the Railroad Commission issued order No. 20-5036, effective July 7, 1943. This order provides for relief to be granted to leases that are unable to comply with the water-oil ratio order after a hearing setting out the circumstances and the relief desired.

By its Order No. 6-6167, effective May 1, 1944, the Railroad Commission revised the bonus oil rules by providing that bonus allowable be calculated on the basis of water production by individual wells. No bonus is allowed on water in excess of 400 bbl. for any well, and the bonus earned by any well cannot exceed the well's oil production. As 1 bbl. of bonus oil is allowed for each 50 bbl. of water injected this means that a well producing 6 bbl. of oil daily cannot earn bonus oil for water injection in excess of 300 bbl. of water daily. Order No. 6-6167 also contained a provision for a lag of one month between the injection of water and the production of the bonus allowable. This provision ended a first of the month stampede to determine monthly water volumes, get the proper forms filed and approved by the Railroad Commission, and notify the lease pumper how much bonus was assigned to each of his wells. It is the opinion of those charged with handling the bonus oil that this provision also contributed to the winning of the war.

Railroad Commission Order No. 6-6838, effective October 20, 1944, was designed to assist the Commission in

TABLE 5
Statistical data from Railroad Commission well status reports.

	4-1-41	12-15-41	6-15-42	12-15-42	7-1-43	1-1-44	7-1-44	1-1-45	7-1-45
Flowing wells making water	759	1118	961	877	888	843	1086	1045	1029
Pumping wells making water	3682	4017	4010	3935	3735	3832	3786	3784	4027
Pumping wells not making water	3146	3115	3220	3392	3333	3348	3257	3500	3519
Gas lift wells making water	458	524	559	535	530	502	472	412	258
Gas lift wells not making water	429	455	439	462	526	532	527	516	490
Total pumping wells	6828	7132	7230	7327	7068	7180	7043	7284	7546
Total gas lift wells	887	979	998	997	1056	1034	999	928	748
Total artificial lift wells	7715	8111	8228	8324	8124	8214	8042	8212	8294
Total Woodbine water wells	4363	5659	5530	5347	5153	5177	5344	5203	5317
Marginal water wells	757	927	1006	959	1004	1120	1198	1276	1295
Proratable water wells	3606	4732	4524	4388	4149	4057	4146	3927	4022

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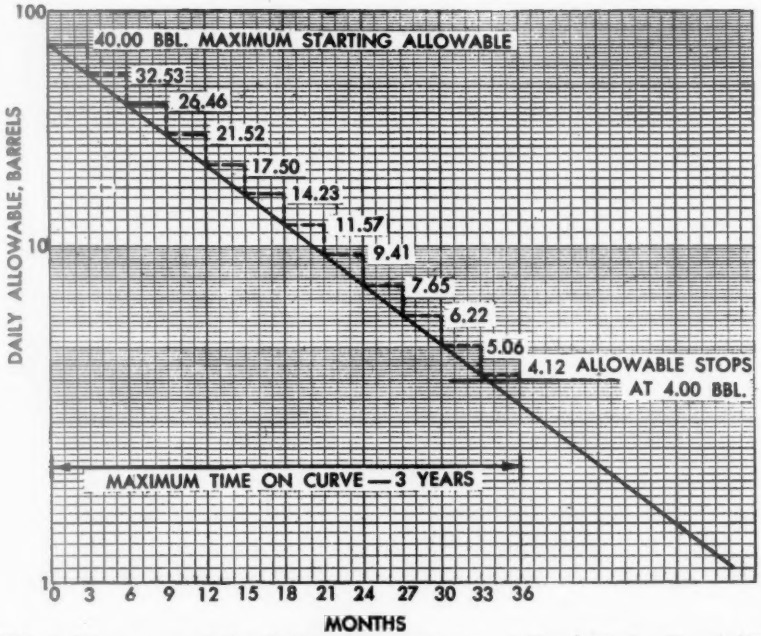

FIG. 4. The curve of the Railroad Commission of Texas Order No. 6-4571. Effective March 16, 1943. Under this order the allowable may not be greater than 40 bbl. nor less than 4 bbl. per day. The starting allowable is based on a 72-hr. test and it is reduced on the first day of the month at quarterly intervals by applying the factor, .81325.

maintaining bottom-hole pressure test wells in the east side low pressure area and in the west side water producing area in order that its pressure surveys may continue to reflect true conditions in the field. This order allows the transfer of allowable from a bottom-hole pressure test well to the other producing wells on the lease when natural flow in the test well ceases. This order was necessary because bottom-hole pressures cannot be obtained in pumping wells with the desired accuracy without removing the rods.

These orders have been enumerated and described in chronological order rather than by groups according to the subject in order to show how these rules were made to fit conditions as the need arose and were promptly amended as conditions changed. Growth of this body of rules was necessary for its success. It would have been impossible for anyone to sit down in December of 1941 and draw up a set of workable orders to prevent permanent damage to the East Texas reservoir without causing irreparable damage to the East Texas operators.

★ ★ ★

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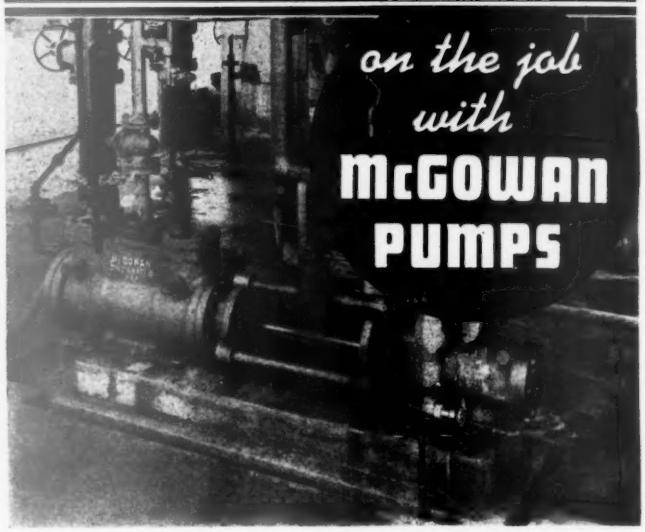

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HUMBLE INITIATES AIR PATROL OF PIPE LINE

HUMBLE PIPE LINE COMPANY of Houston, Texas, has inaugurated its first airplane pipe line patrol over a portion of its network of lines. The company has purchased a small Luscombe plane, a two-place ship, which the pilot inspector will fly. Looking out his window at 500 ft. or lower, he will inspect the grounds over the pipe lines for tell-tale oil spots and other disturbances that might need the attention of repair crews.

Humble Pipe Line Company officials have carefully worked out the route the new pilot inspector is to patrol. The pipe lines have been plotted on flight maps, so at all times the pilot will know where he is in relation to the nearest pipe line pump station. In mapping the route, as much dead flying as possible has been eliminated by making it a near circuit.

The section of line to be patrolled will be about 915 miles in length entailing 1050 miles of flying. It will take the pilot inspector two days to make the route on one patrol, officials estimate. He will inspect pipe lines from Baytown to McCamey in West Texas via Webster, Hearne, Comyn, San Angelo, and Big Lake, returning via Yates, Pecos, Big Lake, Humble Pipe Line Station C, which is about 40 miles from Kerrville, Seguin, Luling, West Columbia, and back to Webster. Scheduled fueling stops are Waco, McCamey, and Seguin.

By inaugurating the use of the plane on this route, one man will be able to patrol an area formerly covered by several line walkers, and these line walkers will be transferred to other suitable positions in the company, Humble officials explained.

Until the company is able to procure a wave length and equipment for operating its own two-way communication system between the plane and the pipe line pump stations, a system of signals will be used. The inspector is to keep before him an aerial patrol report form, and should he find trouble on the lines, he fills in the form, giving the location of the leak. The form then is attached to a small sand bag, and when he arrives at the nearest pump station on schedule, he drops the sand bag and circles until he sees it is picked up by pump station personnel.

In choosing a pilot for such a position it was necessary to find a man who not only can fly but who knows pipe lines and what to look for in inspecting them for trouble, officials pointed out. The first pilot inspector is R. R. Roberts, veteran of 23 years with Humble Pipe Line Company and for a number of years district gager in the Mexia area. Roberts has been flying for years and holds his commercial license with instrument rating and instructors rating.

"Humble Pipe Line Company, in initiating this circuit, recognizes that the airplane must now be considered in the same light as any other type of work equipment. From the experience of other companies and by Humble under contract patrol, this type of line inspection has proved far more satisfactory and considerably more economical," officials stated. ★ ★ ★

Humble Pipe Line Company officials gathered at Houston municipal airport recently to greet the arrival of the first plane scheduled for pipe line patrol duty between Baytown and McCamey. Left to right: Pilot, R. R. Roberts; assistant general superintendents, H. M. Stevenson and F. D. McMahon; A. E. Payne, superintendent of the Southern division; and F. O. Perry, district superintendent at Pierce Junction.

OBTAINING AND PRESENTING FOUNDATION DESIGN DATA

By **TRENT R. DAMES**
Dames and Moore, Civil Engineers

THE art of procuring and using foundation design data has received its greatest impetus from the new science of soil mechanics, which has experienced its principal development during the last 25 years. Soil mechanics has been defined by Karl Terzaghi, under whose direction most of the early research in this field was carried out, as "The application of the laws of mechanics and hydraulics to engineering problems dealing with sediments and other unconsolidated accumulations of solid particles produced by the mechanical and chemical disintegration of rocks, regardless of whether they contain an admixture of organic constituents." In a field of such great breadth, it is necessary to limit this paper to some small phase of this field.

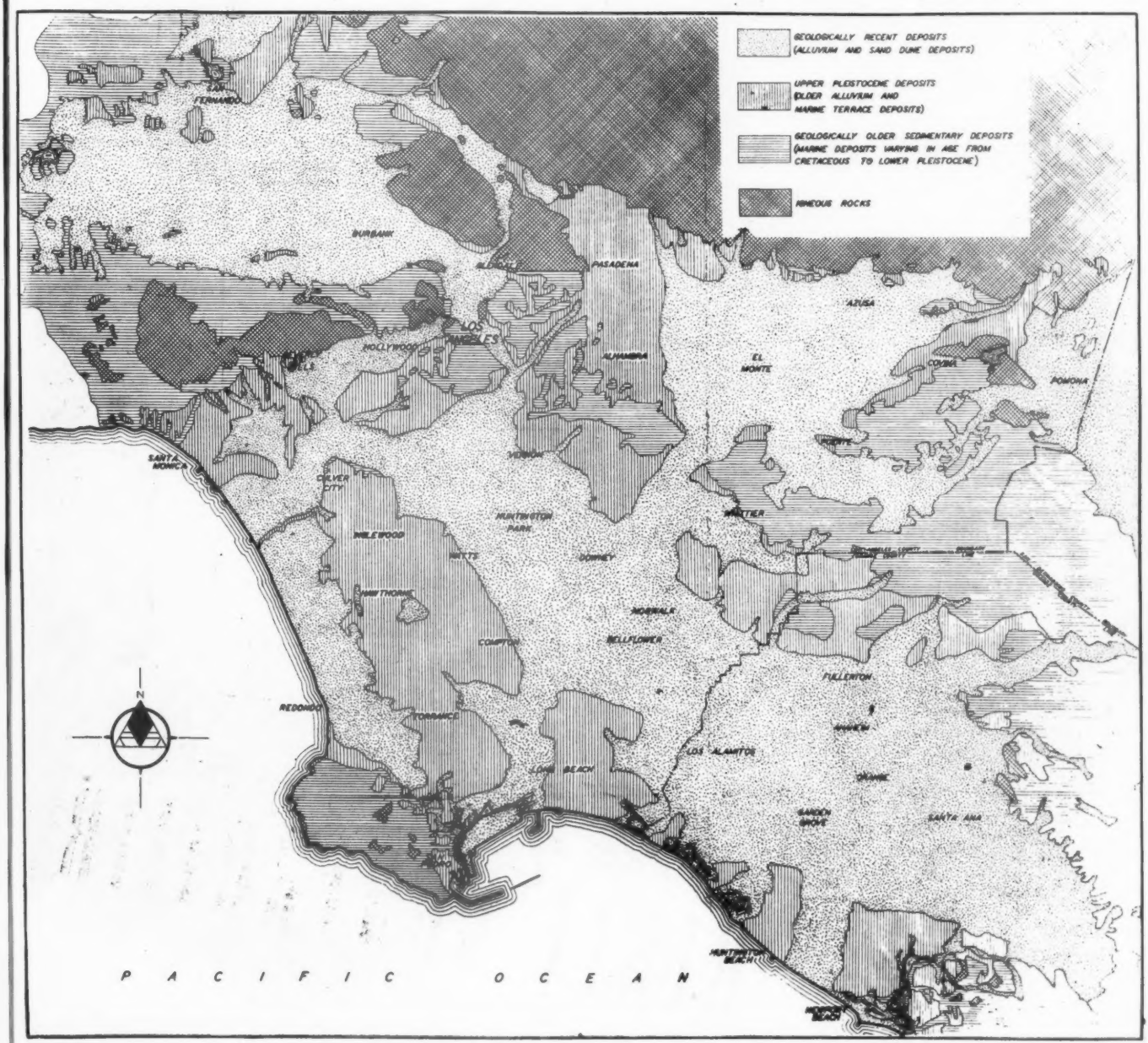
Before going into a discussion of the details of the subject, I should like to outline briefly some of the important phases of the field of soil mechanics in order to illustrate the scope of this field. Soil mechanics deals with what the geologist calls "mantle" or "regolith," but which to the civil engineer is commonly known as soil or earth. The field of soil mechanics is one that is rapidly changing as the scope of our knowledge thereof increases. New research is continually being reported and continually modifying the practical applications of this science to engineering problems. As is the case in all new fields, the questions that cannot be answered far exceed in number those that can be answered, and most of the latter can be answered only imperfectly. Development of the science has advanced to the point where it is a very considerable aid in the solution of certain critical engineering problems, however, among which are the following:

1. Investigations of the character of the foundation soils present on the site

(Continued on Page 184)

*Presented before California Natural Gasoline Association, September 6, 1945.

FIG. 1.



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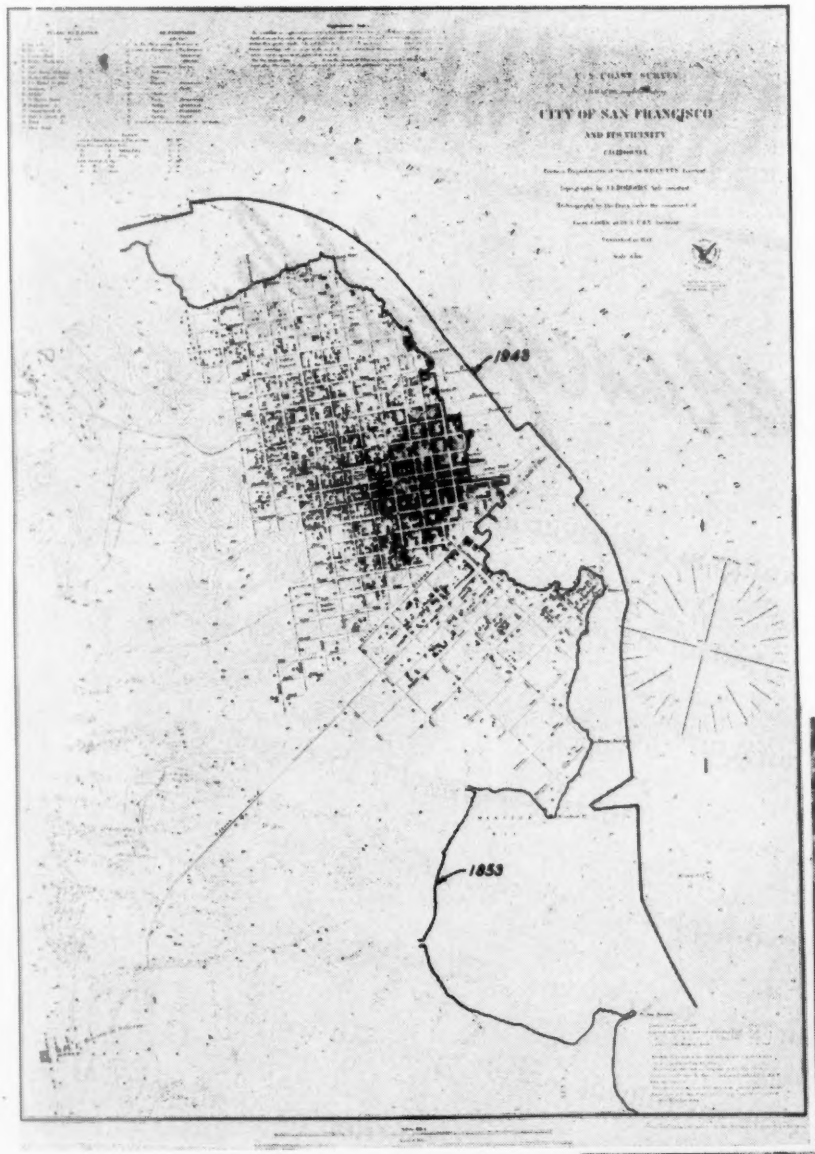


FIG. 2.

(Continued from Page 181)

of a prospective development for the purposes of:

a. Evaluating the costs of developing a potential industrial or commercial property;
b. Planning the development of a selected property in order to enable the arrangement of structures to take advantage of varying foundation conditions;
c. Determining, after the site and plant arrangement have been selected, the type or types of foundations best suited for the support of the particular structures planned;
d. Determining specific design values for particular foundations so that safe and economical foundations for the support of a particular structure on a particular site may be obtained.

2. Analyses of conditions that have led to objectionable settlements of existing structures, and a feasible means of correction.

3. Analyses of the stability of earth embankments, excavations, etc., and of the lateral forces on retaining walls, quay walls, etc.

4. Investigations of the materials available for the construction of all types of earthfill structures, the methods of placing these materials to the required quality, and the design of these structures to resist the loads that will be imposed upon them.

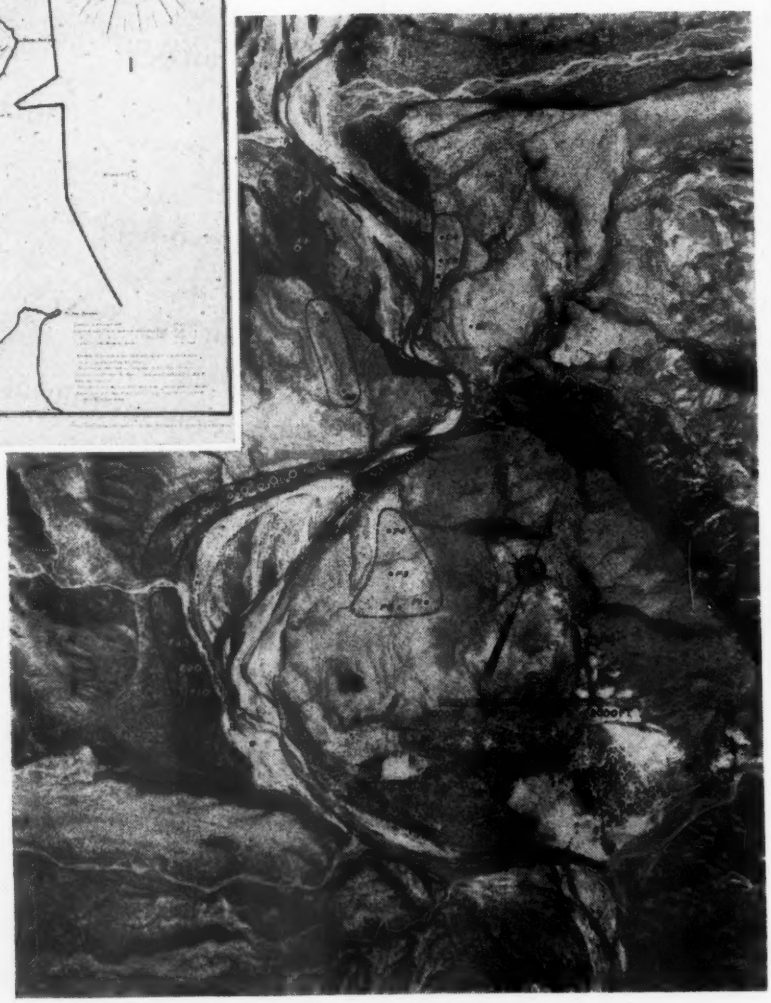
5. Investigations of the support offered by subgrades to the various kinds of roadway, airport, and plant pavings.

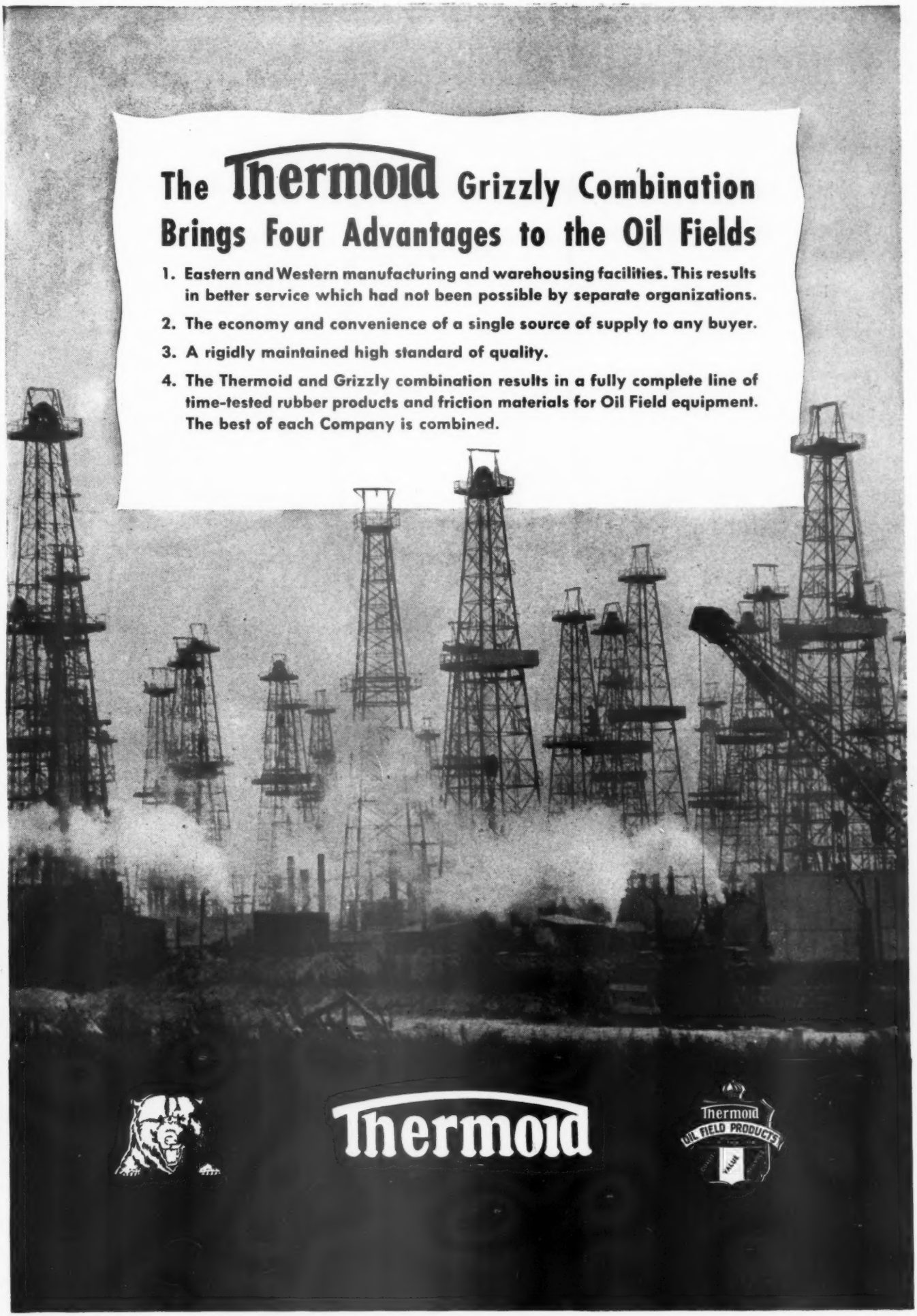
After this brief introduction to the field of soil mechanics, I shall now present a more detailed discussion. The procuring of foundation design data generally requires the performance of a foundation investigation, the purpose of which is to provide data concerning those physical properties of the soils that will influence the foundation design, and, in many cases, the structural design. No foundation investigation should be undertaken without a reasonably thorough planning of the exploration program. It should be expected that these plans may have to be revised as the investigation progresses and new information becomes available.

BEFORE an investigation may be planned satisfactorily, it is necessary that some thought be given to the foundation requirements of the proposed structures. For example, a one-story steel-frame factory building would require a different type of foundation investigation than a catalytic cracking unit, even though the soil conditions were identical.

Having in mind the foundation re-

FIG. 3.

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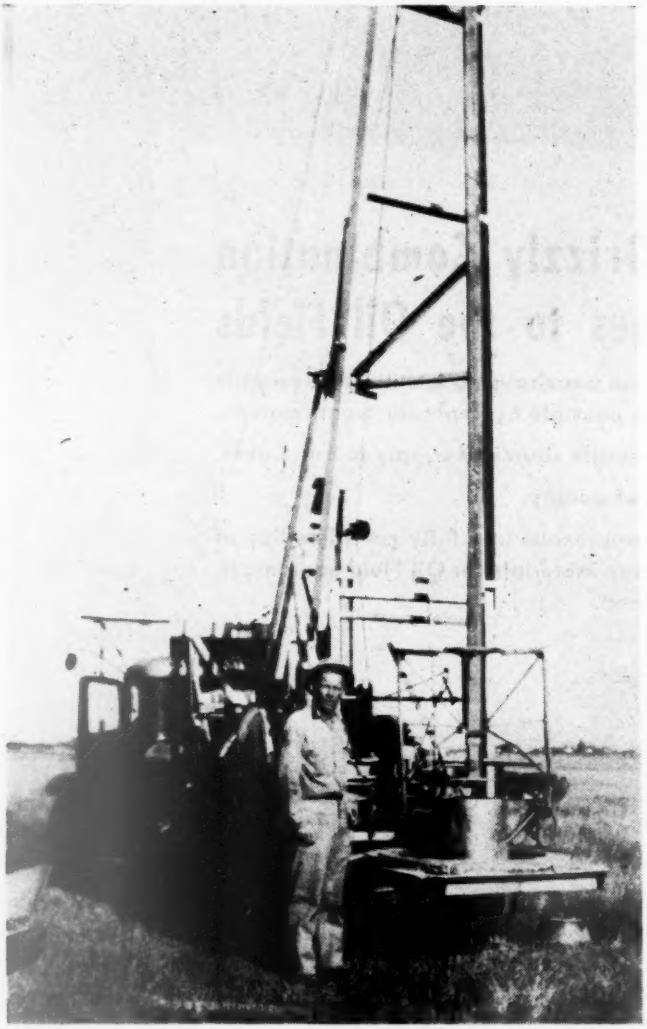


FIG. 4.

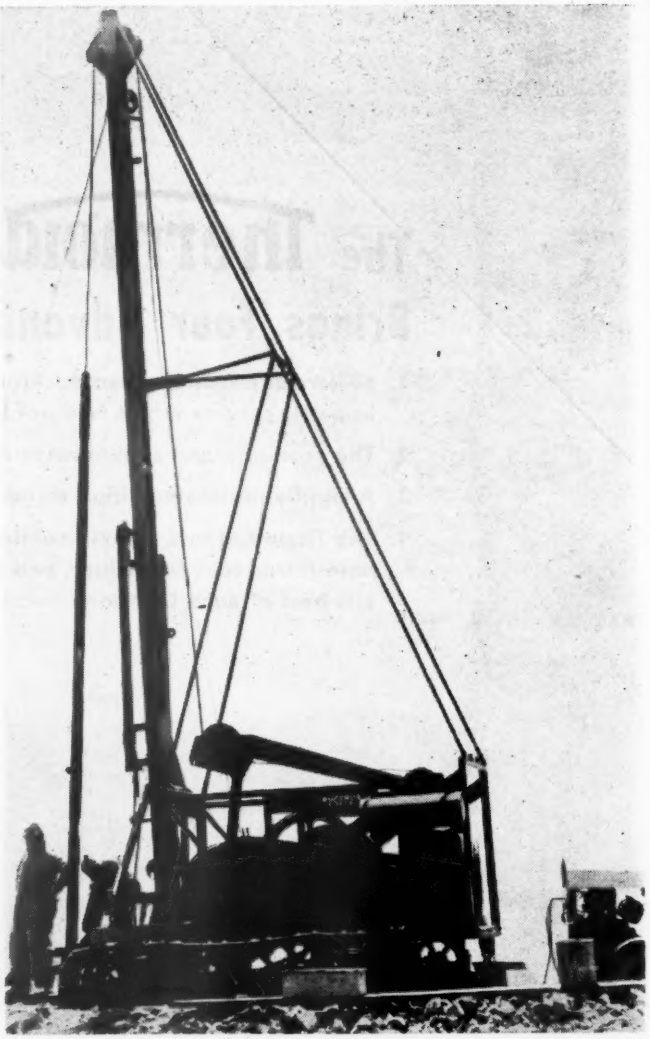
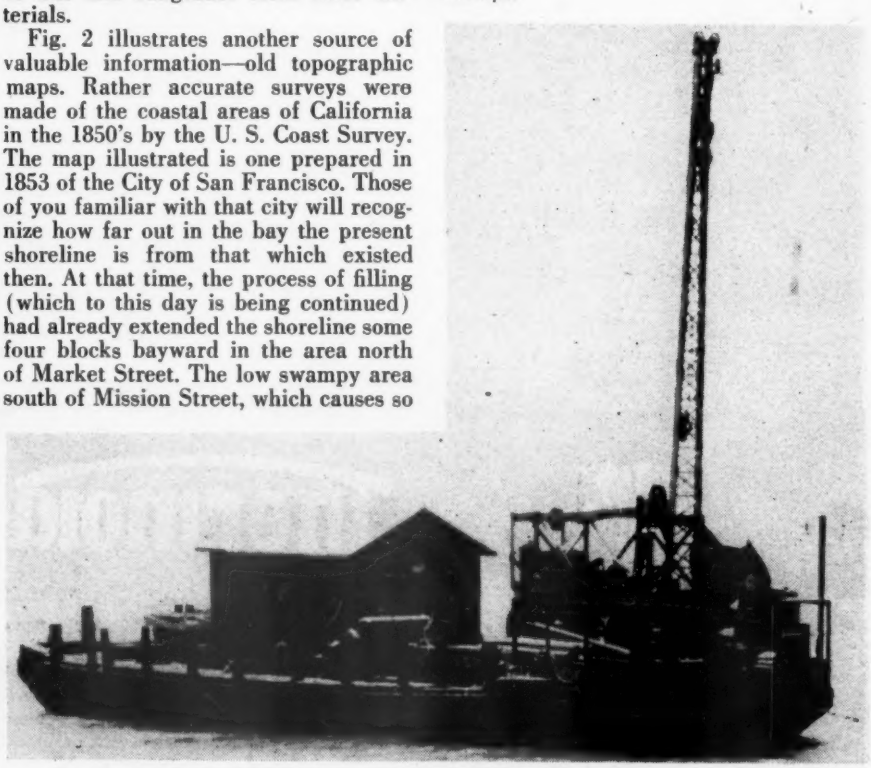


FIG. 5.

quirements, the foundation engineer will normally consult geologic source data. Fig. 1 shows a simplified geologic map of the Los Angeles area—the grouping of geologic divisions chosen is that having the greatest foundation significance. The areas designated as Geologically Recent Deposits generally contain soils of very recent origin ranging from soft clay and silt near the ocean, to firmer sandy loam and compact sand and gravel nearer the mountains. You will note the large areas of Upper Pleistocene Deposits. The soils associated with these deposits, although they may appear similar to the recent soils next to them, have been appreciably consolidated and, in general, offer much better foundation support than the recent deposits. Unfortunately, however, the upper surface of the Upper Pleistocene Deposits (and also the Geologically Older Sedimentary Deposits) has, in general, been rendered unfit for foundation use by weathering and decay, which has formed a so-called "adobe" topsoil. The Geologically Older Sedimentary Deposits and the Igneous Rocks offer adequate foundation support for practically any structure but present a variety of interesting problems in the stability of slopes, percolation of ground waters, and construction of fills and subgrades from these materials.

Fig. 2 illustrates another source of valuable information—old topographic maps. Rather accurate surveys were made of the coastal areas of California in the 1850's by the U. S. Coast Survey. The map illustrated is one prepared in 1853 of the City of San Francisco. Those of you familiar with that city will recognize how far out in the bay the present shoreline is from that which existed then. At that time, the process of filling (which to this day is being continued) had already extended the shoreline some four blocks bayward in the area north of Market Street. The low swampy area south of Mission Street, which causes so

FIG. 6.



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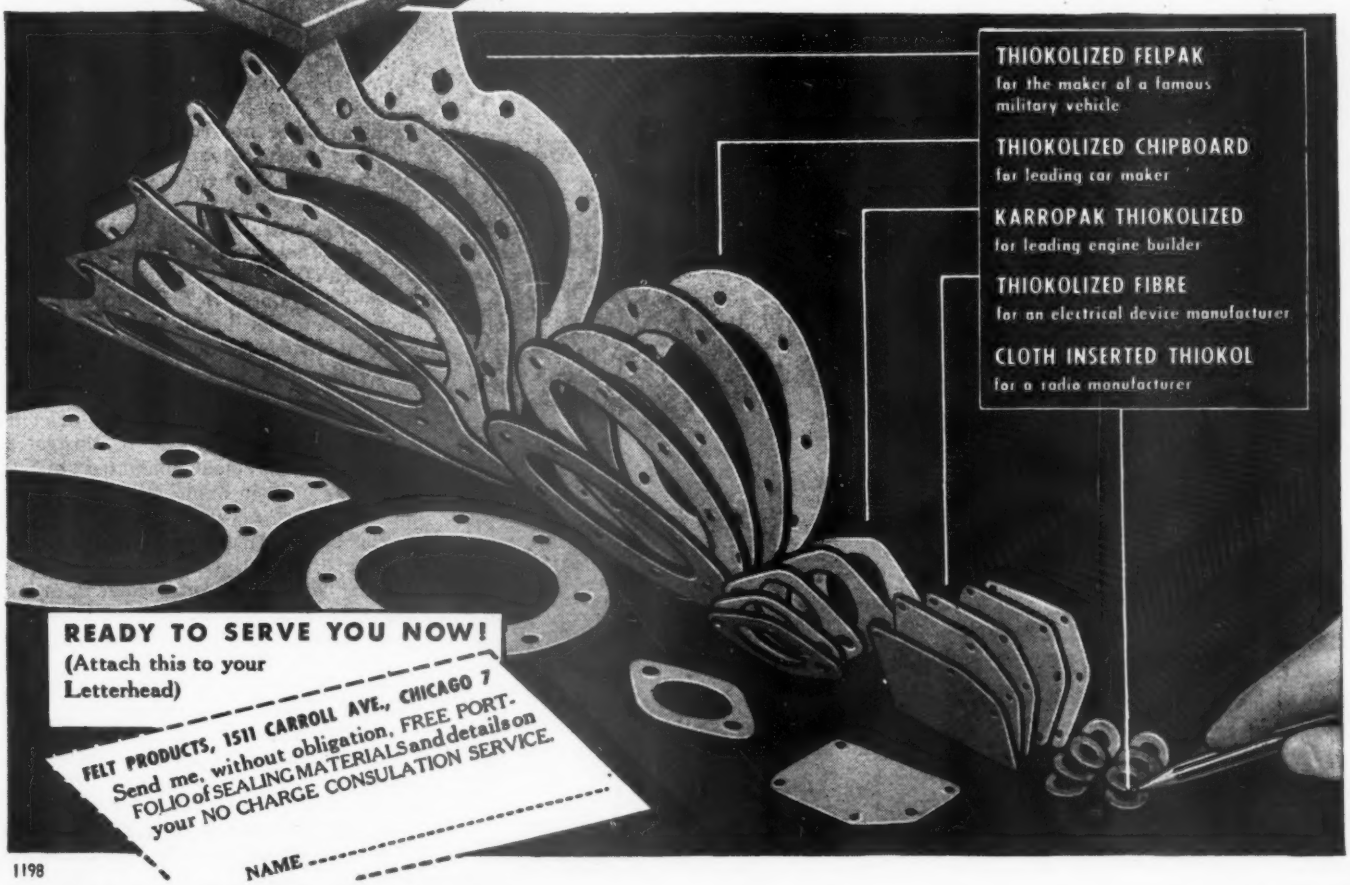
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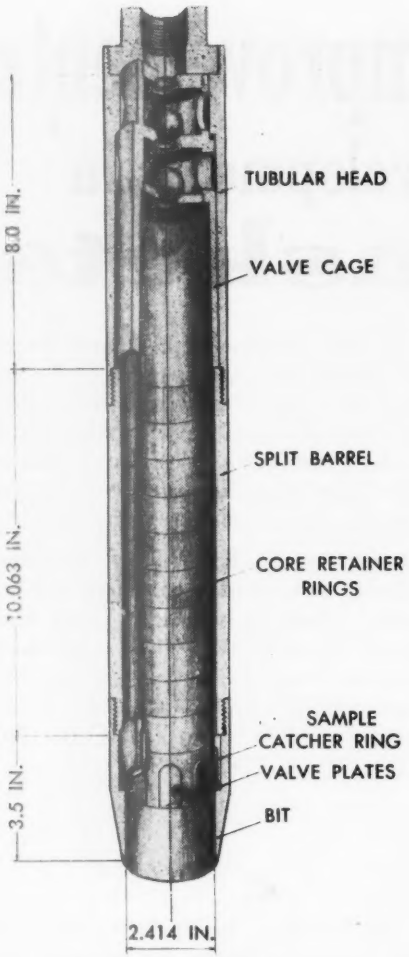


DAMES AND MOORE
SOIL SAMPLER

FIG. 7.

many difficulties in foundation construction in that area, is clearly evident on the old map.

Aerial photographs are another source of valuable information, particularly in selecting sites for development. At certain seasons of the year, the color, type, and density of the vegetation when seen from the air will disclose soils of differing geologic character. Fig. 3 shows a view of an area in central Arizona that was being investigated to determine the suitability of the available soils for use in construction of an earthfill dam. Areas of different geologic character are readily distinguished.

The records of other investigations and logs of wells and borings made in the vicinity will also be consulted. Unfortunately, in many cases investigations made on adjacent property are made for other purposes and do not provide useful data. Well logs, in particular, are notoriously unreliable.

Design and settlement records of buildings and structures in the vicinity will also be studied to provide pertinent information.

AFTER he has obtained all the available structural and soil data, the foundation engineer will decide the number and depths of borings necessary to determine, with sufficient accuracy for engineering purposes, the foundation conditions on the site. The borings should determine the distribution of soil strata to the depth of influence of the pressures that will be imposed on the soils by the probable foundations. The depth of influence is generally assumed to be two and one-half times the foundation width below the bottom of the foundation.

If very shallow explorations will be sufficient, the soils may be explored by the use of hand-dug pits. Ordinarily, the depth of influence is so great as to require the drilling of borings. These borings may be advanced by any one of several methods, depending upon which method is best suited to the particular soil conditions.

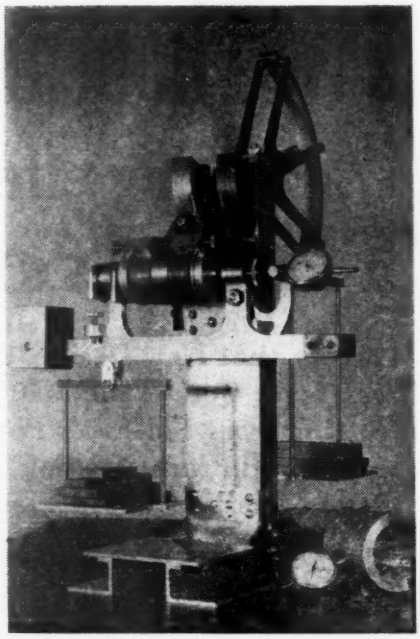


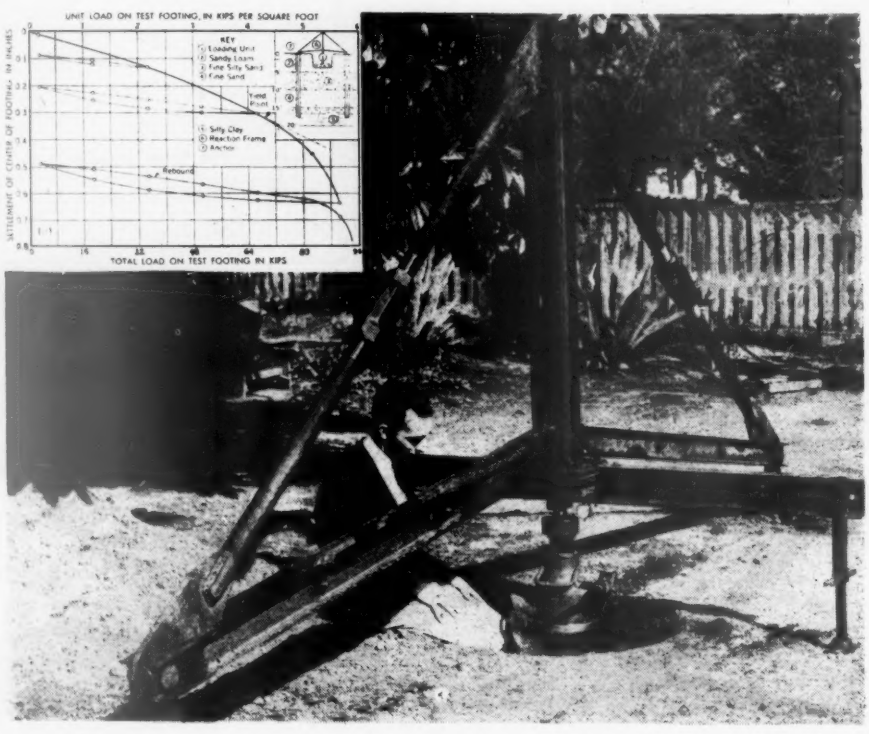
FIG. 9.

The truck-mounted rotary-bucket type of drill rig illustrated by Fig. 4 frequently is used where the water table is low and the soils will stand in an uncased boring without caving. This type of drill rig rapidly drills a large-diameter hole that an inspector can enter to examine the soil in place. However, this rig is not particularly suited to advancing borings below the ground water level and/or in caving soils. If explorations below the ground water table are to be made, wash-boring equipment generally is best suited. Unfortunately, such borings cannot be advanced economically through rocky fills and compact sand and gravel, in which case other equipment must be used.

Fig. 5 illustrates a cable-tool type of drill rig. Inasmuch as casing is always used with a cable-tool rig, this rig is particularly suited to drilling below the ground water level and is capable of advancing borings through rocky fills, compact sand, gravel and boulder deposits, and even bedrock. The use of any type of drilling equipment is not restricted to drilling on land. Fig. 6 illustrates cable-tool equipment mounted on a barge, as used in explorations for marine structures in San Francisco Bay.

The several methods of exploration that have been illustrated serve only to advance an exploration boring. In order that full value may be realized from the explorations, undisturbed samples of the soils in their natural state must be procured. These samples are normally obtained by driving a sampling device into the undisturbed soils at the bottoms of the exploration borings. The sampler illustrated on Fig. 7 consists of a tubular driving head, a split tubular barrel, and a tubular bit, one end of which is ground to a cutting edge. Into the driving head

FIG. 8.



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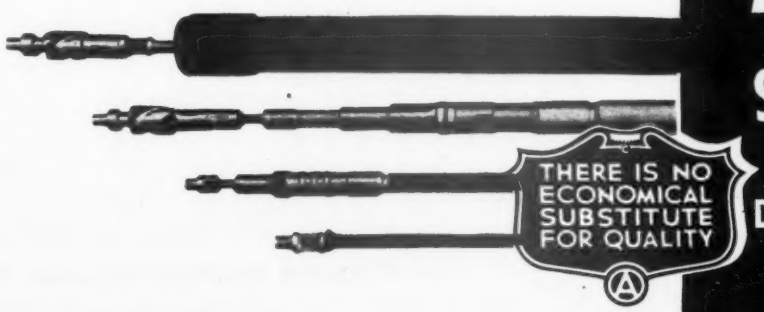

NAVY

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SUCKER RODS

AND

DEEP WELL PLUNGER PUMPS

SHEARING FAILURE IN SOIL
(Below an overloaded wall footing)
Soil—Recently deposited dirty sand and shaley gravel of low density.
Footing depth—18 in. ± below ground level.
Footing width—2 ft. 3 in.
Load—2300 lb./sq. ft. of actual load vertical cut through footing and supporting soil.
Left—Unretouched photo. Right—retouched to show outline of shearing failure. Solid line—Observed (for eccentrically loaded footing). Broken line—Theoretical (for concentrically loaded footing).

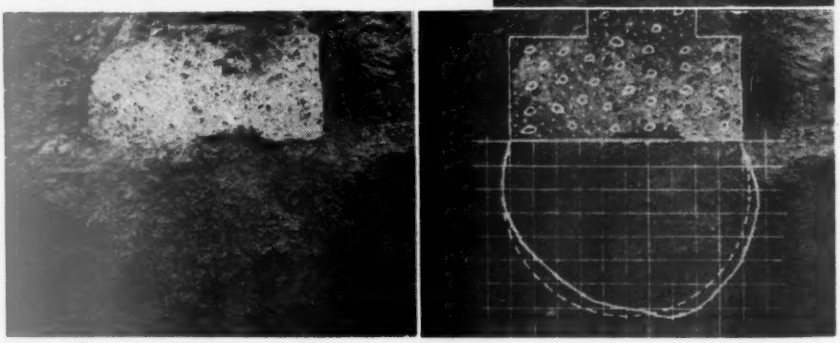


FIG. 10.

Location of footing.
(Building being torn down.)

is fitted a valve cage designed to permit the upward passage of water but not its downward return. This tends to create a partial vacuum that helps to hold the sample in the barrel as the sampler is withdrawn. The barrel contains a series of core retainer rings that supports the sample throughout all handling and testing. Into the bit is fitted a catcher device that serves to close the opening after the core of soil has been taken and the sampler is being retracted.

There are many modifications and variations of the types of explorations that have been so briefly discussed. In addition to the outlined methods, jointed test rods or test piles may be advantageously driven when the sole purpose is that of sounding through soft overlying layers to determine the depths to the upper surface of a firm stratum below. This method particularly may be used when it is desired to interpolate information between exploration borings.

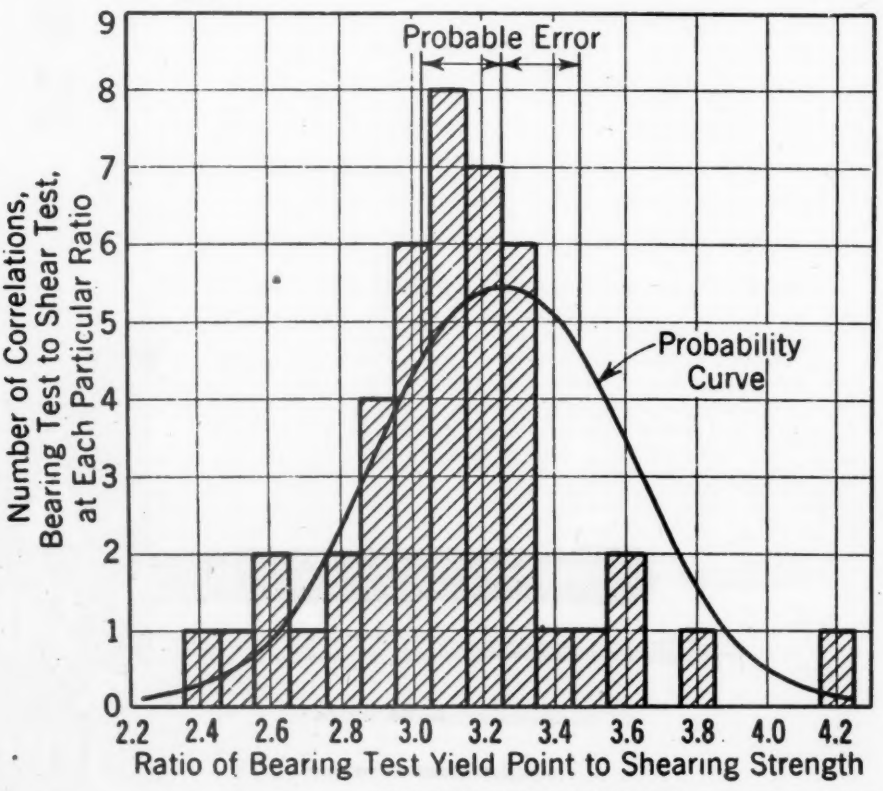
Geophysical means of foundation exploration, although probably offering many opportunities for development, to date have not met with very general usage in the field of foundation investigation. These methods have been applied in determining the contours of the upper surface of rock beneath dam sites and in locating sand and gravel deposits.

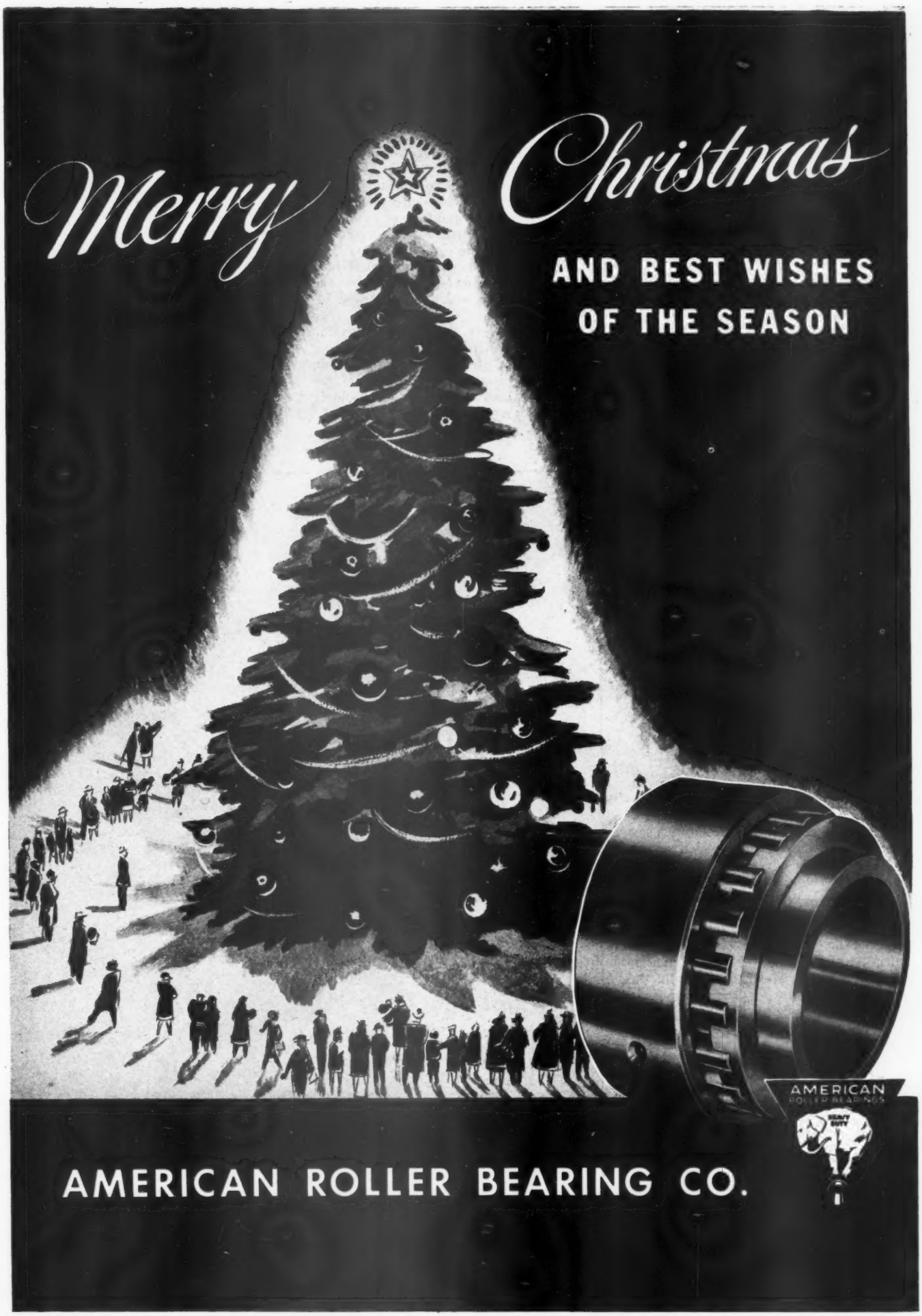
It should be emphasized that explorations, to be worth their cost, must be supervised by trained personnel to obtain accurate and complete records. Too frequently the drilling of exploration borings is carried out under the supervision of personnel whose education and training do not provide them with a background adequate for evaluating the relative importance of what the explorations disclose as they progress, and appreciating the significance of these disclosures in warranting changes in the prepared program of exploration.

FIELD load tests, such as illustrated by Fig. 8, were, up until a relatively few years ago, the only means of making physical measurements of the behavior of foundation soils. Essentially, these tests are performed by loading a small test footing and measuring the resulting deflection. The loads are applied in increments and the deflections measured by accurate means, as by micrometer dial gages. Each increment of load is maintained until the deflection has substantially ceased. The load-deflection curve obtained from these data describes only the behavior of a footing of the same size, at the same depth, and under the same conditions of confinement as the test footing. The curve, as illustrated by the typical example on Fig. 8, usually consists of a straight line or approximately straight line portion followed by an increasingly curved segment representing an increasing rate of deflection with increasing load.

All that field load tests of soils actually measure is the shearing strength of the soils. Some ten years ago, Robert V. Labarre, Frederick J. Converse, William W. Moore, who is the writer's partner, and the writer, investigated the possibility of substituting laboratory performed shear tests on undisturbed cores of soil for field load tests. A mathmetical derivation of the relationship between the shearing strength and the load that may be imposed on a loaded area (i.e., a footing), is to be found in Timoshenko's "Theory of Elasticity" and indicates that the bearing value is equal to Pi times the shearing strength. In order to determine whether theoretical relationship, which was derived for an isotropic homogeneous elastic body, would apply to soils, experiments were conducted with shear tests performed on undisturbed cores of soil. One type of apparatus now used in the performance of such tests is shown by Fig. 9. A three-ring core of soil is subjected to normal, or axial, loads equivalent to the confinement that the soil is or will be under in the field, the center ring then being sheared from between the other two. A load-versus-shear-deflection curve is then plotted from which the yield point shearing strength of the soil is determined. A comparison of the yield point shearing strengths with the bearing values obtained from field load tests indicated that the theoretical relationship was valid for soils within

FIG. 11.

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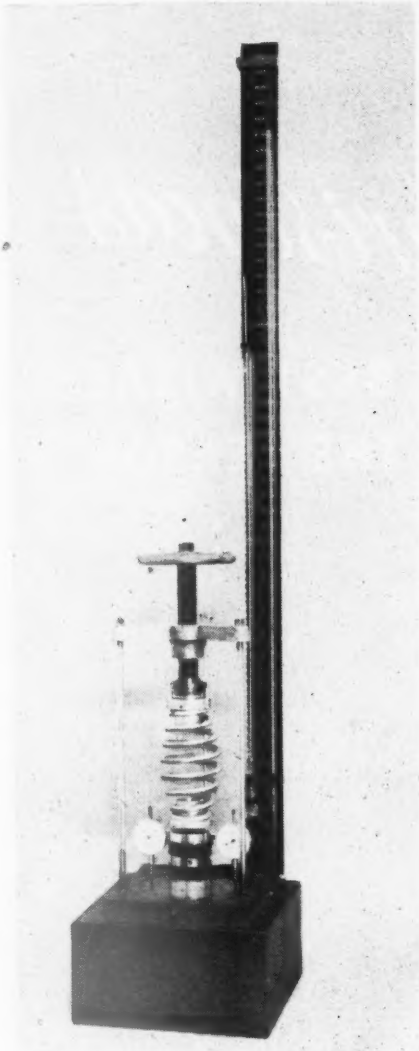


FIG. 12.

limits of engineering accuracy. The nature of this shearing failure on a bulb-like surface beneath a loaded footing is illustrated by Fig. 10, which shows a section of a footing that has settled severely. A probability curve, Fig. 11, has been prepared by comparing the yield point bearing values determined by some 50 load tests on nearly every kind of soil and the results of shearing strength determinations on these same soils. This curve indicates that for any particular determination of shearing strength, the bearing value can be predicted with a probable error of approximately 10 per cent, which is sufficiently accurate for engineering purposes. Inasmuch as a sample may be extracted and a shear test performed thereon for a fraction of the cost of a field load test, it is now practical to test samples obtained from a variety of depths and at a variety of locations over a site. Such a procedure enables the determination of average values, which are far more reliable for design purposes than the results of a single load test or even several load tests.

Shear tests may also be used as a basis for calculating the supporting capacities of piling. If this is desired, friction tests would be made on materials used in the shear tests in order to determine the friction of the soils on the pile materials.

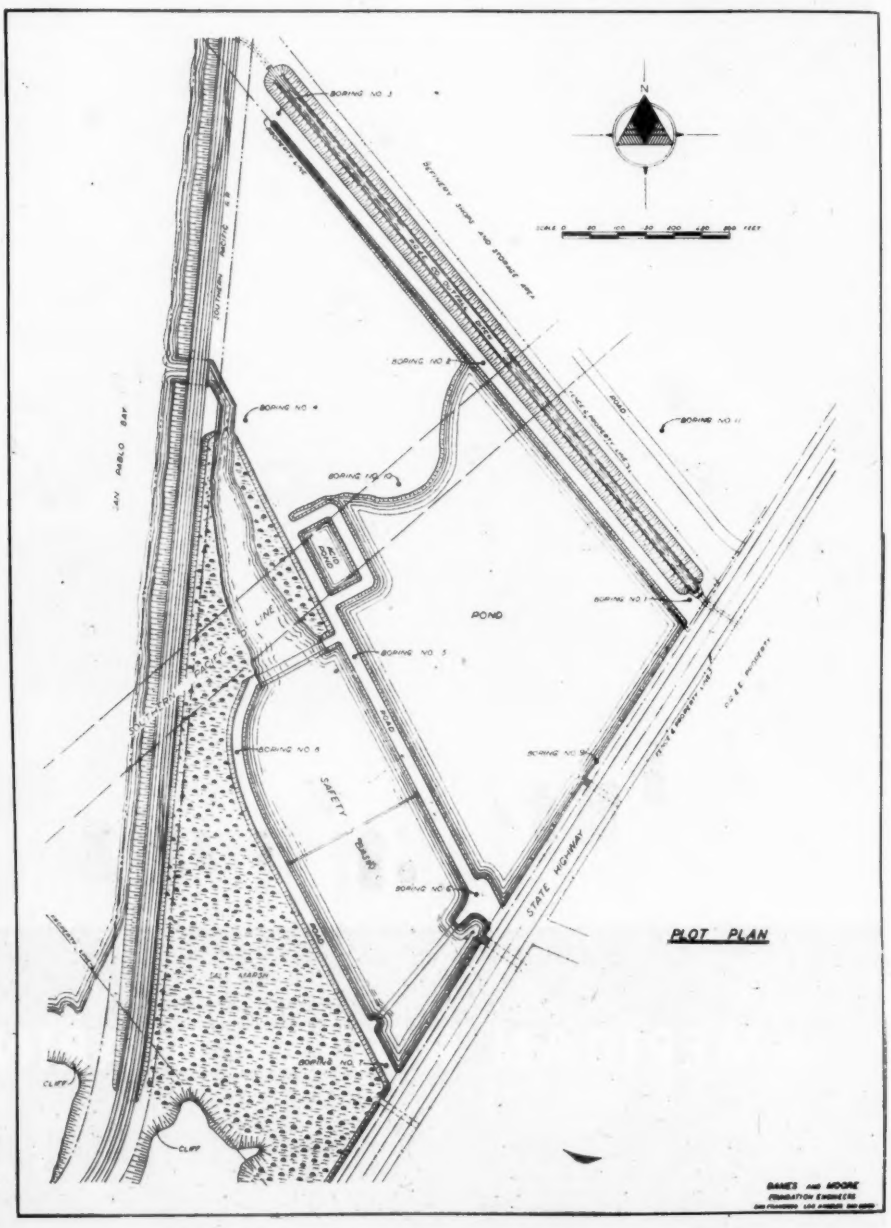
THE shear test, however, determines only that unit load at which the soils will begin to flow from beneath a footing. It does not permit a determination of how much a footing will settle under load. To obtain data concerning the compressibility of the soils to be loaded by a foundation, consolidation, or confined compression, tests are performed. Fig. 12 illustrates one type of apparatus used for the performance of these tests. A confined sample of soil is placed between two porous stones, normal load applied in a series of increments, and the compression with time recorded for each increment.

Unfortunately, the load deflection curve obtained from the results of these tests will not plot as a straight line on an arithmetic scale. The shape of the curves obtained varies with the geologic history of the soil and other factors and does not follow any known laws. The general form suggests, however, that soils in compression have a modulus of elasticity that is some exponential function of the load. The data obtained from consolidation tests when used with curves indicating the distribution of compressive stresses beneath a loaded area permit the calculation of the settlements that may be expected for a particular footing. Unfortunately, the settlement calculations are not as accurate as the bearing value determinations; errors of on the order of 50 per cent must be anticipated.

The shear tests and consolidation tests are the basic tests employed by the foundation engineer today. It might be well, however, to mention several of the other types of tests that are used frequently.

Expansion tests are performed by permitting a core of the soil to absorb water by capillarity and measuring the expansion of the sample at various time intervals. The sample is subsequently removed from the apparatus and allowed

FIG. 13.



Through the war years, the cost of the job was secondary to *getting that job done.* But from now on, COST—both operating and maintenance—will be the all-important factor in the purchase of new heavy-duty equipment for drilling, pumping, generating and well servicing. When it comes to deciding what kind of power will operate that equipment at lowest cost, don't overlook the proved-on-the-job advantages of Cummins Dependable Diesels . . . their demonstrated reliability and long life . . . their easy, economical maintenance and service . . . their 12-year proved record of producing faster, cheaper footage.

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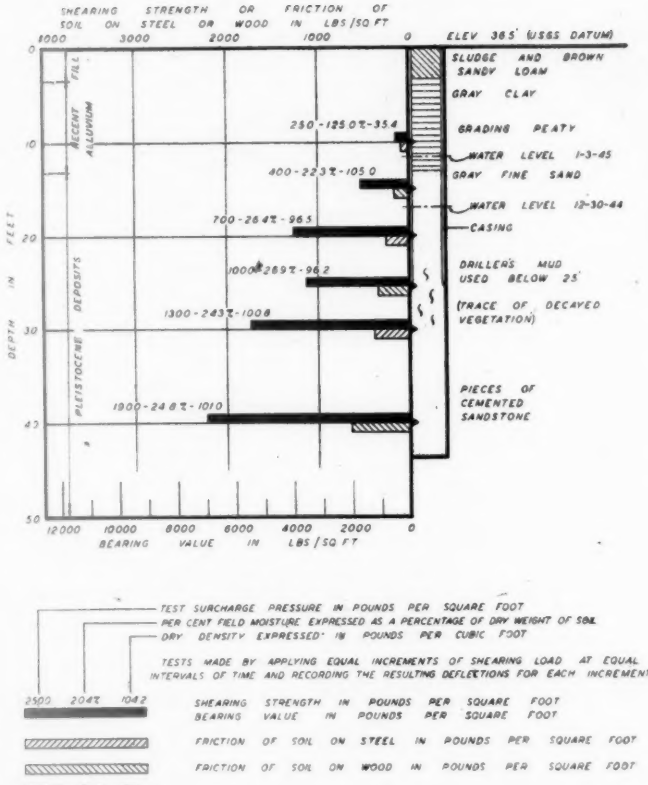

SHEARING STRENGTH OR FRICTION OF SOIL ON STEEL OR WOOD IN LBS/SQ FT
ELEV 36.5' (USGS DATUM)
SLUDGE AND BROWN SANDY LOAM
GRAY CLAY
GRADING PEATY
WATER LEVEL 1-3-45
GRAY FINE SAND
WATER LEVEL 12-30-44
CASING
DRILLERS MUD USED BELOW 25'
(TRACE OF DECAYED VEGETATION)
PIECES OF CEMENTED SANDSTONE
250-125.0%-35.4
400-223%-105.0
700-264%-96.5
1000-269%-96.2
1300-243%-100.8
1900-24.8%-101.0
RECENT ALLUVIUM
PLEISTOCENE DEPOSITS
DEPTH IN FEET
BEARING VALUE IN LBS/SQ FT
TEST SURCHARGE PRESSURE IN POUNDS PER SQUARE FOOT
PER CENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF DRY WEIGHT OF SOIL
DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
TESTS MADE BY APPLYING EQUAL INCREMENTS OF SHEARING LOAD AT EQUAL INTERVALS OF TIME AND RECORDING THE RESULTING DEFLECTIONS FOR EACH INCREMENT
2500 204% 104.2
SHEARING STRENGTH IN POUNDS PER SQUARE FOOT
BEARING VALUE IN POUNDS PER SQUARE FOOT
FRICTION OF SOIL ON STEEL IN POUNDS PER SQUARE FOOT
FRICTION OF SOIL ON WOOD IN POUNDS PER SQUARE FOOT

FIG. 14, Top.

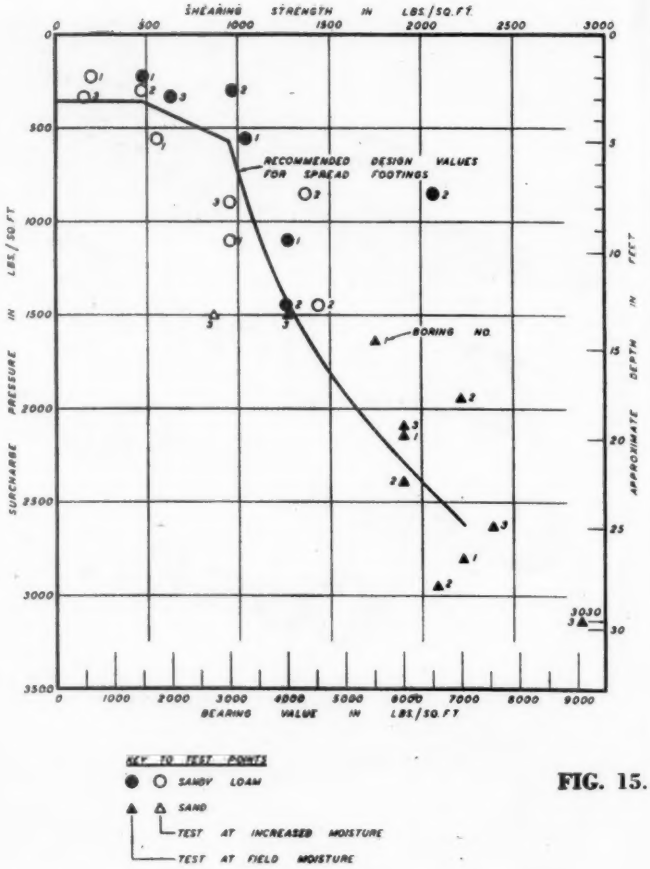
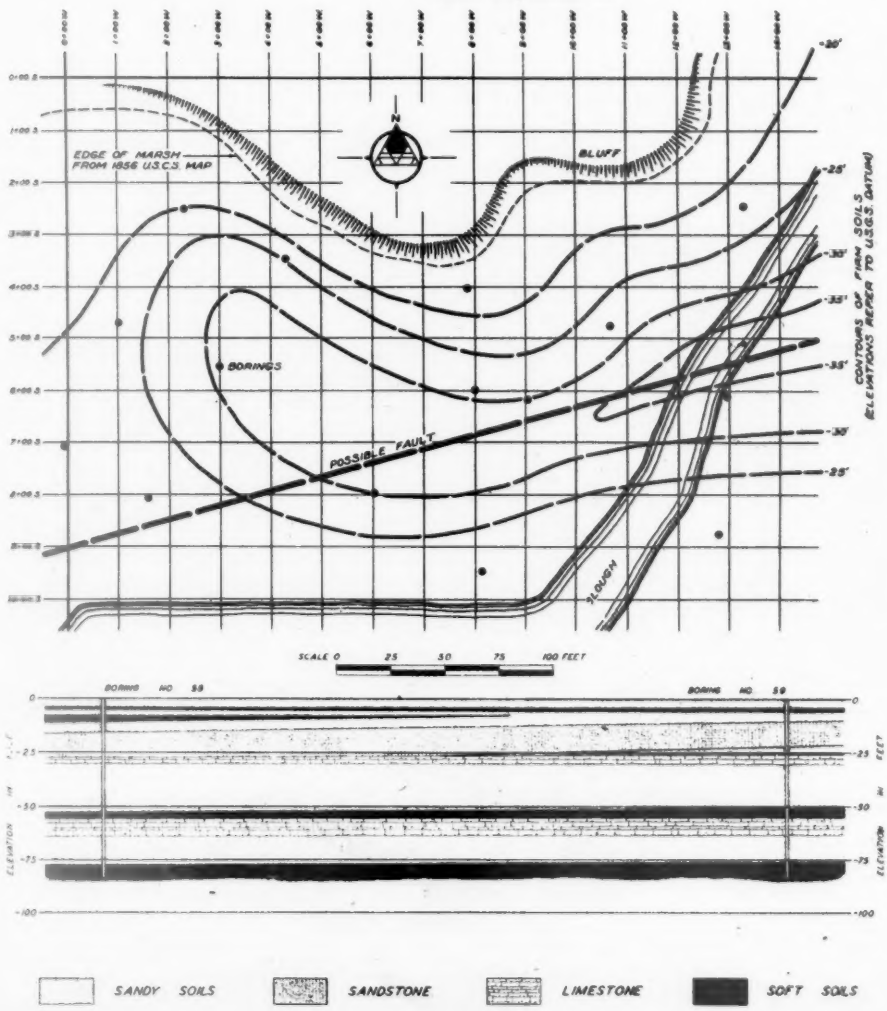


FIG. 15.

FIG. 16, Center.

FIG. 17, Bottom.



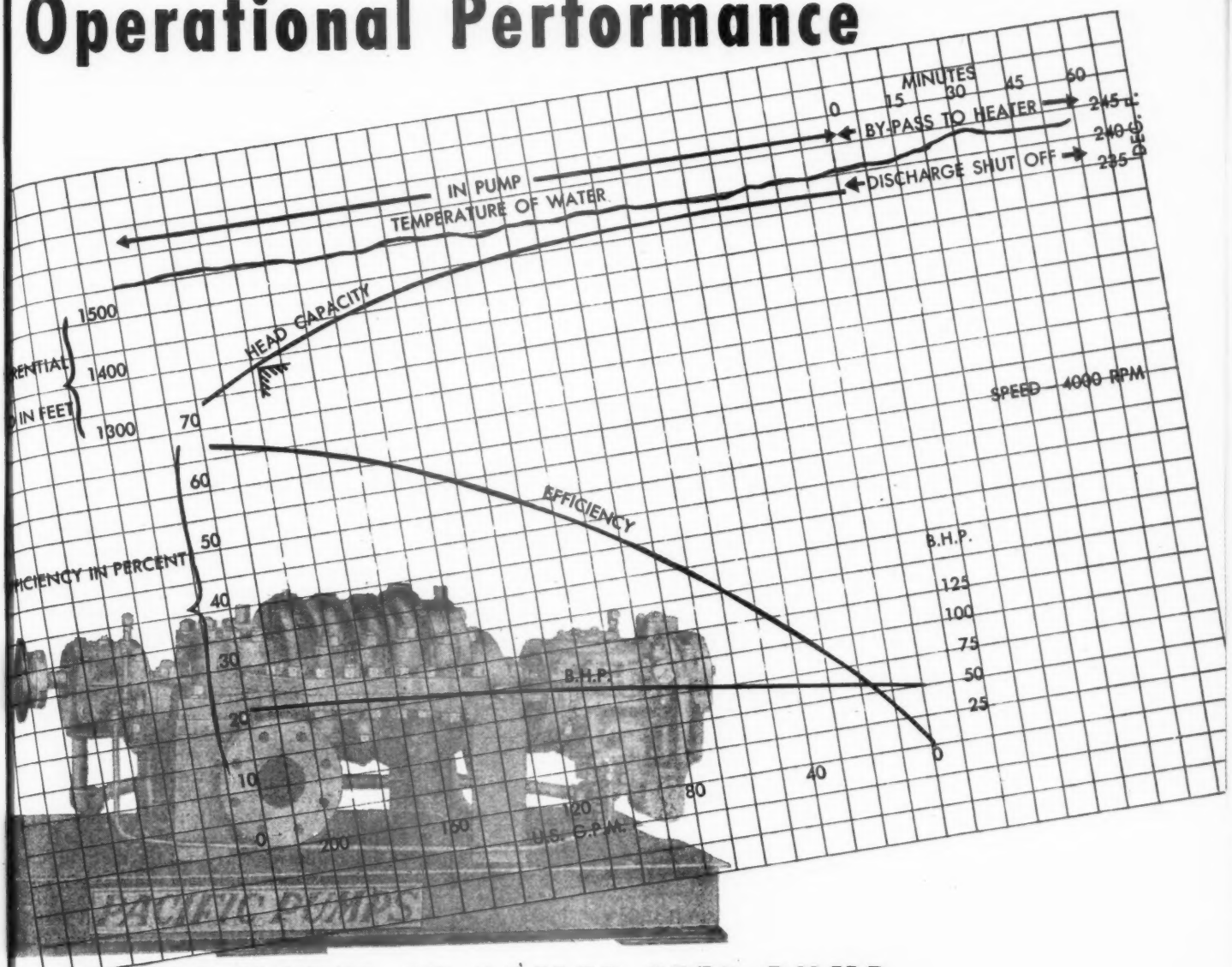
to dry at room temperature, after which it is further dried in an oven. The resulting contractions are measured for each case. This test is important in predicting the behavior of "adobe" soils, which are susceptible to large volume changes with changes in moisture content.

Compaction tests are frequently performed to determine the densities to which a proposed fill soil can be compacted by a given compacting energy. These tests determine an optimum moisture content at which the soil may most effectively be compacted using a specified compacting effort. When used in conjunction with shear tests and consolidation tests on cores prepared from the compacted soils, the tests enable the design of compacted fills for the support of foundations and pavements.

Percolation tests determine the resistance that the soils offer to the flow of ground waters. These tests are performed by placing a confined core of soil between porous disks and applying a surcharge equivalent to the confinement at which it is desired to study the sample. The confined sample is subjected to a known head of water, and the quantity of flow through the sample is measured over a period of time. These tests are useful in studying the time-rate of settlement of structures on certain types of soil, but their more particular use is in the design of earth structures, such as earth dams and levees.

Having performed the necessary explorations and tests, the foundation engineer has arrived at the point where most engineers begin their analyses and designs. A structural engineer, for ex-

Operational Performance



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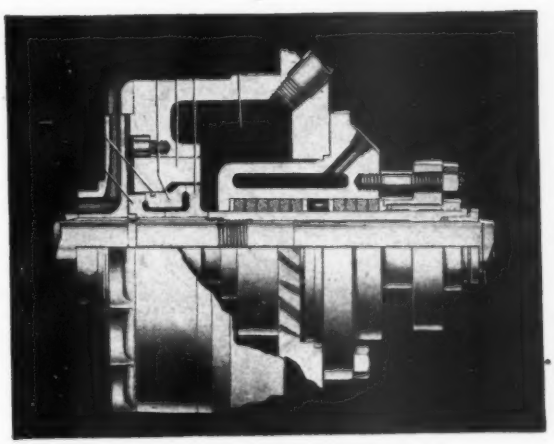


(A) Low Pressure Seal Plate. (B) High Pressure Seal Plate. (C) Seal Bushing. (D) Piston Ring. (E) Seal Housing. (F) Chamber with By-pass Line.

PACIFIC *Engineered* PUMPS

ample, is not required to perform investigations for each new job, for he has access to numerous data regarding the properties of the structural materials with which he works. It is his job skillfully to use and combine materials of known physical properties into a useful and economical structure. The foundation engineer, however, must first obtain the necessary data and then present these data in terms suitable for use by himself or others. So many variables are present that graphical means usually offer the most satisfactory medium for the presentation of these data and even graphs are inadequate in many cases.

In the graphical presentation of the data, a plot plan recording the locations at which the explorations were conducted is almost always required. The plot plan on Fig. 13 shows the relationship of the explorations to the property lines and existing structures.

The results of field explorations are almost always most effectively presented in terms of graphical logs. Fig. 14 shows a typical log of a boring on which is entered, in addition to the soil types and the observed fluctuations of the ground water, such pertinent data as whether casing was required or driller's mud used. The results of the shear and friction tests on samples extracted from the boring are usually presented in the form of bars on a graph adjacent to the graphical log. The upper scale of the graph indicates the shearing strength or friction strength of the soil, whereas the lower scale indicates the bearing value.

Usually the shearing strengths and corresponding bearing values so presented cannot be effectively used unless the data from several borings are summarized. Fig. 15 shows a typical summary. Where the problem permits the use of such a simple presentation of the facts, a line is passed through the data, thus providing the structural designer with the bearing values that he may use safely at any depth.

In the case just illustrated, the bearing value increased with depth in accordance with some physical law. Another common case is that of weak strata overlying a much stronger body of soil, which possesses a uniformly high bearing value but an irregular surface configuration. In this case, the depths to which foundations must be carried may be presented advantageously by subsurface contours describing the surface of this body. Fig. 16 shows a typical presentation. Often it is advantageous to show the arrangement of soil strata in the form of a subsurface section, as illustrated by Fig. 17.

Very commonly the soils may be so soft as to preclude the utilization of spread footings for the support of any important structures and the use of piling may be required. The writer and his partner have developed a method of computing static supporting capacities of all the various types of pilings commonly employed. This method is based on the determined shearing strength and friction of the soils penetrated by the piling. The method permits an evaluation of the downward frictional drag that recent fills placed over soft soils frequently exert as the soft soils consolidate under the action of the loads of the newly superimposed fills. The results obtained from this method of analysis, a description of which is beyond the scope of this paper, have been verified by the performance of load tests on piling. Fig. 18 shows one method of presenting data concerning the supporting capacity of piling.

Under most circumstances, particularly for the type of soil condition illustrated by Fig. 18, driving formulas provide wholly unreliable results. In most cases, the capacities indicated by driving formulas are extremely conservative, whereas in a few cases, such as that illustrated, the formulas give a false sense of security, the error only being realized after the usefulness of the finished structure is destroyed by destructive differential settlements. An outstanding example of such settlement is shown by Fig. 19, where the pile has settled on the order of 0.3 ft., the pile having moved completely away from the structure that it was intended to support.

Figs. 13 through 18 represent only the most basic and most frequently required data. Many special problems arise that require more complicated investigations, analyses, and methods of presentation. It is regretted that a discussion of even a few of the more interesting of these problems would prohibitively increase the length of this paper. If the paper has indicated some of the means of obtaining and presenting reliable foundation design data, its purpose will have been accomplished.

★ ★ ★

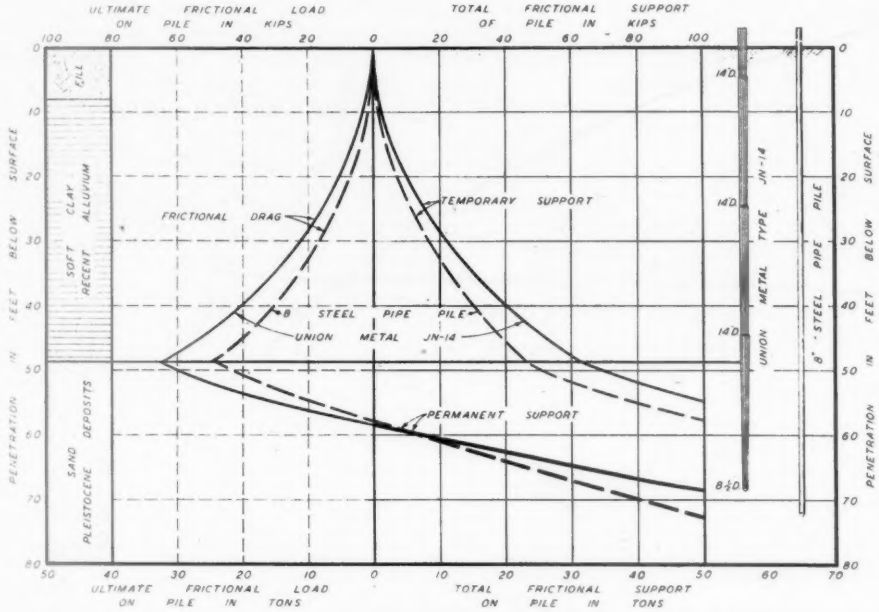
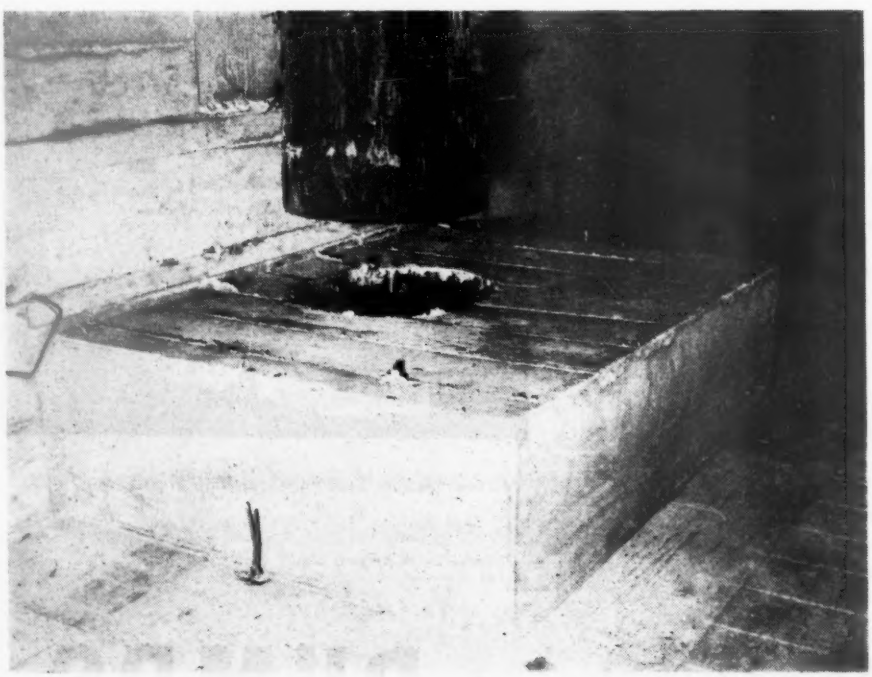
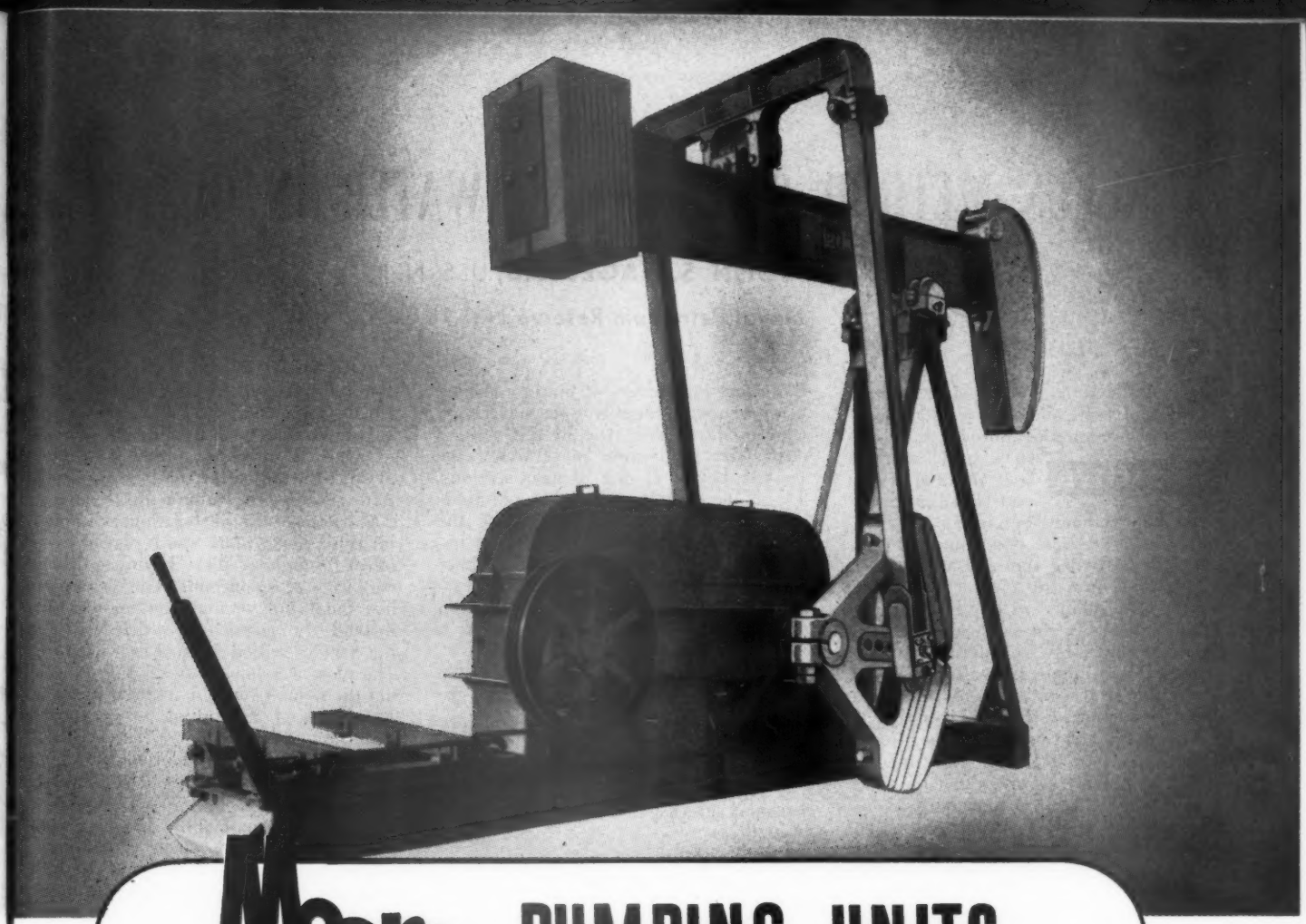


FIG. 18, Above.

METHOD PATENT NO 2,296,466

FIG. 19, Below.





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Naval Petroleum Reserve No. 1

EXCLUSIVE

THE accepted method of locating water in most oil wells takes place under nearly static pressure conditions. Although this method has been successful, several disadvantages must be overcome before an accurate water entry can be determined. In an effort to overcome these disadvantages, a new procedure for "Water Witching" has been developed, whereby the operating pressure in the well bore remains the same under test and producing conditions. The water entry will be located while the well continues to pump its daily production of oil and water.

The normal procedure in locating a water entry in a wet well is to pull the tubing and, if necessary, clean the hole to bottom. The well is then bailed continuously for a short period of time to remove the static pressure head and start the movement of fluids into the well bore. The hole is then conditioned with electrolyte and a traverse of the perforated section made by the water locating device. Additional bailing is necessary to continue the movement of fluid into the hole. The amount of bailing required after each successive traverse of the hole will depend upon the productivity index. If the well has a large productivity index, a large amount of fluid will have to be withdrawn to result in any appreciable pressure drop in the well bore. This point is particularly true if the percentage water cut is low.

WATER conditions usually found in wet producing wells are as follows:

1. The static pressure of a water producing sand is higher than adjoining oil sands.

2. The higher static pressure of the water entry has developed secondary water entries into dry sands by so-called backed-up water from the well bore. This condition is most noticeable in idle wells.

3. Where the static pressure of the water sand is less than the static pressure of adjoining oil sands, this condition may also develop into secondary water and under normal conditions, is very difficult to locate.

4. In wells with long producing zones, circulation of water sometimes occurs within the zone. This condition should not occur if reasonable care is exercised in pumping the well and will probably be noticeable only when the well reaches static equilibrium.

When it becomes necessary to remove large quantities of fluid to develop a water break, much trouble may be encountered. This is true of the present day short production mast where the longest bailer is one of two sections. This bailer will limit the volume of fluids withdrawn and therefore increase the bailing time. This condition is not important in a regular derrick where larger bailers are possible. The increasing popularity of the short production mast, however, indicates the need for a different technique.

The annulus method of locating water has resulted from many successful annulus wire line runs such as:

1. Pressure surveys.
2. Depth measurements.
3. Depth measurements for determining sand fill-up outside of stuck tubing or drill pipe.

The possibilities of making a successful annulus "Water Witch" run was discussed with one of the water locating companies. Several early experiences of this company prompted them to make a run. The well chosen was UO-NPR-No. 1, No. 37-33S, completed in the Shallow zone at a depth of 2884 ft. Initial production of 216 bbl. a day of oil and 281 bbl. a day of water indicated a wet completion. An attempt at that time to locate water failed because of running sand. The bottom was plugged to 2823 ft. The well was returned to production pumping 245 bbl. a day of oil and 31 bbl. a day of water. The well continued to produce with a low cut until June of this year when the well began pumping at the rate of 582 bbl. a day of water.

New method gives data on water entry obtained while well is producing at normal operating pressure.

Conditions at well No. 37-33S:
Total depth, 2884 *ft., plug* 2823 *ft. Casing,* 7-*in., landed at* 2836 *ft., perforated at* 2785-2836 *ft., C.P.* 2780 *ft.,* 2½-*in. E.U.E. tubing* 2594 *ft.*

The repair crew installed a portable hoist and mast, and lifted tubing out of the tubinghead. A wire line was then run between the 7-in. casing and 2½-in. E.U.E. tubing to determine the amount of sand fill-up. The bottom was found at 2822 ft., indicating the hole was open. After raising the tubing approximately 200 ft. above the perforations, the regular tubinghead plate was replaced by an offset tubinghead plate having a threaded 2-in. hole on one side. The offset plate has the tubing connection on one side instead of in the center, which left room for a hole drilled for a 2-in. bull plug. The plate was landed on the tubinghead, but the bonnet was not screwed in place. This allowed the tubing to be turned with a pair of chain tongs. The well was then returned to production, pumping approximately 100 bbl. a day of water.

After the service company arrived at the well, approximately 1½ hr. were required to rig up, clean instruments, and fill bailer with electrolyte. The bull plug was removed from the offset head, a 1¾-in. 32-ft. bailer and instrument were lowered through the opening. To keep the walking beam from hitting the bailer, it was necessary to stop the pump only while the bailer was lowered through the 2-in. opening. The bailer was then lowered between the 2½-in. E.U.E. tubing and 7-in. 20-lb. casing. No trouble was experienced in running the bailer, in fact, the tubing collars could not be detected. The bottom of the hole was checked at 2822 ft. and with the well pumping at approximately 100 bbl. a day of water, 3 gal. of electrolyte were distributed from 2822 to 2780 ft. Several traverses of the perforated section were made before dilution of the electrolyte appeared. On the third traverse, a distinct break occurred at 2819 ft. On successive breaks, the water entry was enlarged from 2819 ft. to 2821 ft. A total of 9 traverses were made in 35 min. During this time, the electrolyte moved rapidly up the hole in a body at the rate of 2 ft. a min. or 16 bbl. a day. definitely placing the entry of all water below 2819 ft.

THE instrument and bailer were then pulled slowly from the well, passing the bottom of the tubing and reaching the surface without mishap. There was no noticeable pull on the weight indicator as the instrument passed the bottom of the tubing or was pulled from the well. The wire line was found to have a half wrap around the tubing, which was overcome by making a half turn of the offset tubinghead.

Well No. 37-1G was chosen for the

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In Peacetime Transmission Equipment
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These new advancements . . . of far-reaching effect on communications planning . . . emphasize the value of consultation with Federal's engineers. Call on Federal first for the finest in transmission equipment.
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IN 1946

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Now is the time to plan and put in a modern high efficiency Layne Well Water System—a system that will produce great quantities of water at an extra low cost. No investment you can make will show a greater dividend in savings and satisfaction.

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If you wish counsel on preliminary plans for a Layne Well Water System, ask for the cooperation of Layne engineers, which is obtainable without obligation. For illustrated literature, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

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Layne Vertical Turbine Pumps are now available in sizes to produce from 40 to 16,000 gallons of water per minute. Their high efficiency saves hundreds of dollars on power cost per year.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. * Layne-Atlantic Co., Norfolk, Va. * Layne-Central Co., Memphis, Tenn. * Layne-Northern Co., Mishawaka, Ind. * Layne-Louisiana Co., Lake Charles, La. * Louisiana Well Co., Monroe, La. * Layne-New York Co., New York City * Layne-Northwest Co., Milwaukee, Wis. * Layne-Ohio Co., Columbus, Ohio * Layne-Texas Co., Houston, Texas * Layne-Western Co., Kansas City, Mo. * Layne-Western Co. of Minnesota, Minneapolis, Minn. * International Water Supply Ltd., London, Ontario, Canada * Layne-Hispano Americana, S. A., Mexico, D. F.

LAYNE

WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

next run. The same preliminary steps were taken to insure the hole was open to bottom. By lifting the tubing plate out of the head and checking bottom with a wire line through the annulus, a quick decision could be made as to the necessity of pulling the tubing for sand clean out.

Condition of well No. 37-1G:

Total depth, 3275 *ft. Casing,* 7-*in. landed* 3273 *ft., perforated at* 3224-3273 *ft. C.P.* 3218 *ft.,* 2½-*in. E.U.E. tubing* 3050 *ft.* (60 *ft.*-2-*in. on top*).

The well was completed in the Shallow zone at a depth of 3275 ft. Current production was 290 bbl. a day of oil and 175 bbl. a day of water. Several changes were made in the procedure for this well. Approximately 60 ft. of 2-in. E.U.E. tubing was inserted on the top of the 2½-in. E.U.E. tubing and all hung on 2-in. clamps on top of the tubinghead. The use of the clamps gave a more flexible opening than with the annulus head. The same preliminary operations were necessary as on the previous job. The well was pumping at a rate of approximately 375 bbl. a day. The only time it was necessary to shut down the pump was in order to lower the instrument and bailer through the opening at the tubinghead.

No trouble was experienced in running the bailer in the hole. The effect of tubing collars could not be noticed. Pick-up of the instrument was established at 3269 ft. and the hole was conditioned from 3269 to 3200 ft. As on the previous occasion dilution did not occur for several runs. Dilution occurred from 3263 to 3269 ft. on traverse three, four, and five. On successive runs, the water appeared to cone vertically in the zone. This condition appeared reasonable as the sand on bottom was approximately 30 ft. thick. The electrolyte passed rapidly up the hole in a body from 3270 to 3165 ft. in 16 min. or at the rate of 382 bbl. a day. After the electrolyte reached 3165 ft. the pump was stopped and water run in through the annulus. After 16 min., the electrolyte began to migrate downward. The electrolyte moved down from 3135 to 3256 ft. in 26 min. or at the rate 272 bbl. per day. All the electrolyte was forced out between 3255 to 3269 ft. The well was again put to pumping at the same rate as above.

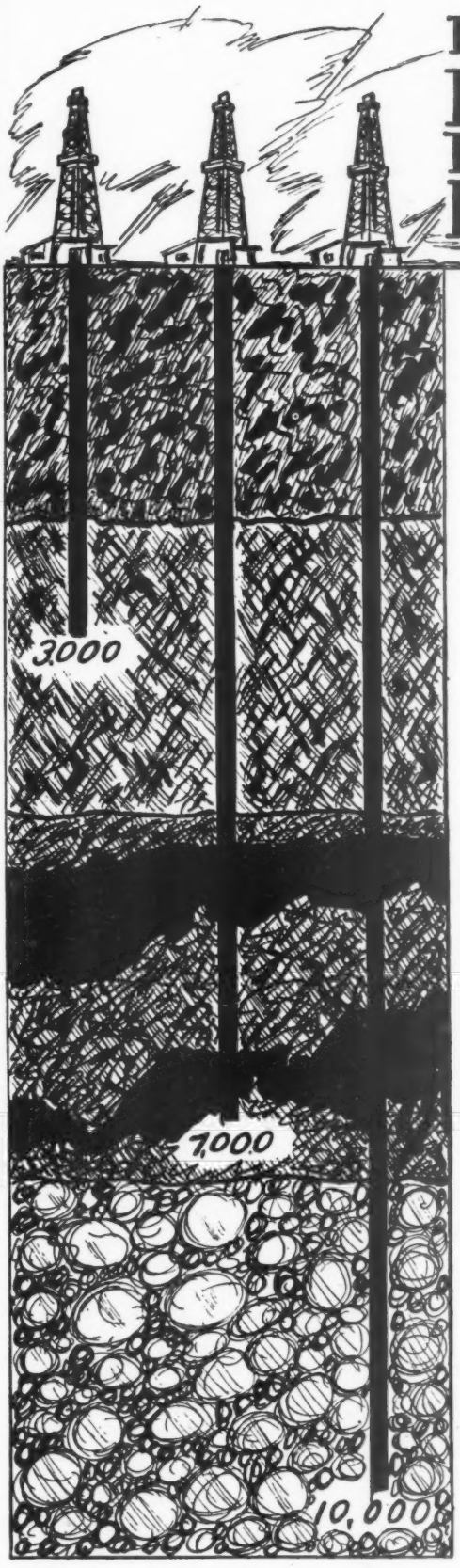
After 20 min., the electrolyte began to return. The fluid entered the 7-in. casing at an average rate of 6.6 ft. per min., which indicated a differential head of 132 ft. or the equivalent to 57.3 lb. per sq. in., drawdown. The returning electrolyte was much weaker than the original concentrations and confirmed the entry from 3255 to 3269 ft. The movement of the fluid downward was valuable knowledge because it indicated the possibilities of plugging off the water entry. It indicated the ability of the sand to take fluid and the necessary head required to drive cement or plastics away. As the instrument was then pulled from the hole, a slight deflection on the weight indicator occurred at each tubing collar. When the instrument reached the surface, the line had a half wrap around the tubing and easily freed itself around the 2-in. E.U.E. tubing.

One advantage of this method was the saving in rig time. The averaged time on a series of water locating jobs that used the conventional method was 21.7 hr., with a time range from 9 to 48 hr. This time required 2 men along with hoist, mast, and tools. With the annulus method, the total time required was 3.5 hr. for one well and 3.3 hr. for the other. It took 35 min. and 16 min., respectively, actually to develop the water entry once the instrument reached the bottom. During the first run two helpers stood by, on the second run one helper was left at the well. The procedure was to leave the hoist and mast at the well; however, the hoist is not needed and can be moved.

To the small operator, the greatest loss is the production that is not recovered because of the down time of the well. In many instances, the well is pulled, effective depth determined, and the well allowed to stand idle while the service company is notified. Often the down time is several days or more before the actual work of locating water gets under way. The amount of lost production, plus the actual saving of time during the work, may easily pay for the cost of the job.

The method described herein opens a new field for oil well repair and development work. This is particularly true when adapted with the small piano wire line and can be most useful in all phases of drilling and production. The use of annulus measurements have been very satisfactory and when holes are reasonably straight and the tubing or drill pipe is in tension very little trouble is experienced. In older wells where casing is bad and "dog legs" are found, some trouble has been experienced. In the older wells, however, larger casing will sometimes offset the hazards encountered. All the work performed to date has been in relatively shallow holes. It is the writer's opinion that this work can be successfully carried on to a depth of 5000 ft.

In conclusion, the methods developed for "Water Witching" by running the water locating device in the annulus have proved very successful. This method gives a quick, concise, sub-surface picture of the water entry while the well is producing at normal operating pressure. The method is very flexible and full control of the electrolyte is maintained at all times. Changes in the procedure can be made to meet individual operating conditions. In wells with 6⅝-in. or 7-in. casing with 2½-in. E.U.E. tubing, it is suggested that several joints of 2-in. tubing be used on top to expedite the removal of the instrument. This method eliminates the need for long standby time when normal production is lost. It does not tie up men and equipment and thereby reduces operating costs. For most wells, the gain in revenue derived from the above savings will more than offset the cost of doing the work. ★ ★ ★



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GAS LIFT

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Yes, indeed. Here is something to remember about pumping deep wells. When you are producing from 7000 to 10,000 feet—the percentage of increase in cost of equipment when you use the Nixon Surface Control Gas Lift is much smaller than that called for with sucker-rod equipment.

The cost of surface equipment of the Nixon Gas Lift remains the same—regardless of depth—the only increase in cost for increased depth being that of additional valves and additional wire line.

And remember—many Nixon Gas Lifts have been operating five years without ever pulling the tubing.

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W. F. Bonner to Midco helm

Randolph C. Walker, president and general manager of the Aireon Manufacturing Corporation, has announced the appointment of William F. Bonner as general manager of the Midco Tool and Supply Company of Oklahoma City, a subsidiary of Aireon.

W. F. Bonner

Bonner comes to his new assignment with a substantial background, both in previous connections and in the Burbank Hydraulics division of Aireon where, since 1942, he was first contract administrator during the heavy war period, and later sales manager for that division.

The new management plans to expand the activities of Midco throughout the United States and to develop its export trade to Mexico and Latin America, as well as the Dutch East Indies.

Announcement also has been made that Bonner and Dr. C. P. Bondurant, of Oklahoma City, have been added to the board of directors. Other Midco directors are Walker, B. D. Craig, and A. E. Welch, all of Kansas City.

Tube Turns plant expansion

George O. Boomer, president of Tube Turns, announces that the board of directors has approved the leasing from the Reconstruction Finance Corporation of $3,000,000 worth of Defense Plant Corporation equipment that had been installed for war work. At the same time, he said, the board also authorized the purchase of additional equipment costing $500,000, to round out the company's production facilities.

When the plant expansion program is completed, Tube Turns will be $3,500,000 bigger than in prewar years and will have one of the largest and most complete manufacturing establishments of its kind in the United States, he said.

Before the war, extensive industrial property at 28th and Broadway, Louisville, was bought for future growth.

Wilson-Snyder manager sales

Howard W. Booth has been appointed manager of sales, Wilson-Snyder Manufacturing Division of Oil Well Supply Company, Braddock, Pennsylvania.

H. W. Booth

Booth was assistant to the chief engineer of Oil Well Supply Company for 12 years, prior to which he served in an engineering and production capacity with Wilson-Snyder.

He entered the employ of Wilson-Snyder immediately after receiving his bachelor of science degree in mechanical engineering from Penn State College in 1930.

Home offices for Oil Well Supply are at Dallas, Texas.

Personnel changes announced

International Harvester Company has announced the following changes in branch management personnel:

C. A. Samuelson, formerly branch manager, Minneapolis, Minnesota, motor truck branch, has been named manager of the motor truck branch at St. Louis, Missouri. Samuelson succeeds J. W. Blackmore who has taken over an International Harvester dealership.

S. A. Hayes, manager at the Seattle, Washington, motor truck branch until the outbreak of the war, has been appointed manager of the Minneapolis motor truck branch succeeding Samuelson. Hayes served in the Army Signal Corps as lieutenant colonel during the war.

E. N. Black, Sr., formerly branch manager at Cheyenne, Wyoming, is now manager of the company's, Springfield, Missouri, branch.

G. C. Murnan, formerly assistant manager, Portland, Oregon, general line branch, has been made branch manager at Cheyenne, Wyoming, succeeding Black.

W. G. Schendel, formerly assistant manager at Pittsburgh motor truck branch and recently lieutenant colonel in the Army, has been appointed assistant manager of the Harrisburg, Pennsylvania, motor truck branch.

G. D. McCarthy, also recently a lieutenant colonel in the Army, has returned to his previous Harvester position as assistant manager of the Philadelphia, Pennsylvania, motor truck branch.

E. E. Krogstad, who served with the United States Navy as lieutenant commander, returns to International Harvester as assistant manager of the Tulsa, Oklahoma, motor truck branch.

W. O. Bolitho, formerly assistant manager of the Cheyenne, Wyoming, branch, returns from the Army, where he served as major, to become assistant manager at the Billings, Montana, branch.

W. C. Habert, formerly assistant manager at the Elmira, New York, branch, has assumed the same position in the West Haven, Connecticut, motor truck branch following service as a captain in the Army.

Wayne Greene, until recently a major in the Army, has been appointed assistant manager at the New Orleans, Louisiana, motor truck branch. Greene served before the war in a similar capacity at the Dallas motor truck branch.

C. T. McCoy to aid sales in Central America

Selected to aid the work of C. C. McDermond as representative for the last 13 years of Axelson Manufacturing Company of Los Angeles, in Venezuela and Colombia, Clifford T. McCoy will carry his long experience of the firm's line of pumps and sucker rods to Central America.

"Mac" McCoy has had more than 22 years' background in the oil industry, having worked for Axelson, Oklahoma, and in the Los Angeles plant. Prior to this experience, he traveled in Canada, worked in the Rocky Mountain fields, and since departing from the Axelson fold was employed for several years with Lacy Manufacturing Company in Los Angeles.

C. T. McCoy

Versed in varied applications of pumps and sucker rods, McCoy also has a thorough knowledge of hydraulics, is a machinist who has dressed tools in the oilfields, and describes himself well as a "bottom-hole pump man." Due to his wide activities and experience, McCoy found it consistent to coin a new word to describe his efforts so far as pumps and sucker rods are concerned; he refers to that particular endeavor as "Pumpology".

The team of "Mac" McDermond and "Mac" McCoy should materially assist in the selling and servicing of Axelson equipment—and promote the "Good Neighbor Policy" with our friends to the south.

Returns to Texoma Supply

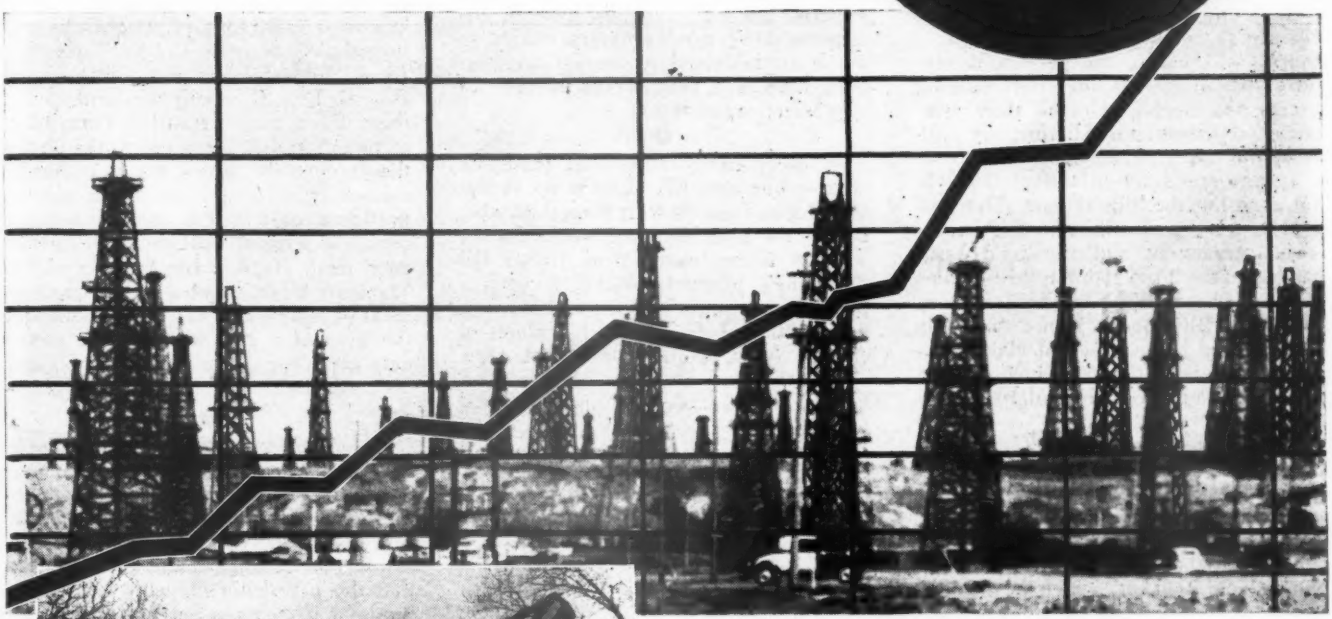
With the return of Lt. James M. Cleary, USNR, to active duty again with Texoma Supply Company, Tulsa, another familiar face has returned to oil country selling circles after an absence of 3 years.

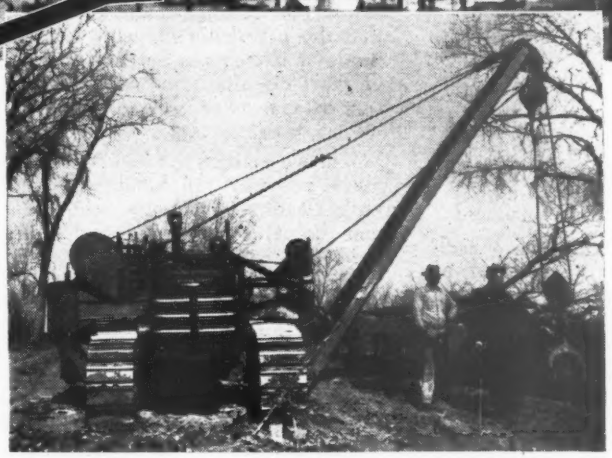
Lt. J. M. Cleary

Cleary, who enlisted in the Navy, May 11, 1942, with the immediate rank of ensign, spent 2 years in the Aleutians. The last year he has been stationed at Norfolk, Virginia, with the Fifth Naval District. His wife, Betty, and 4-year-old daughter Marcia, who have been living with Lt. Cleary at Norfolk, have returned with him to their home in Tulsa.

Cleary, who is a graduate of Oklahoma University, is the son-in-law of Carl J. Hochenauer, president of Texoma Supply Company, and has resumed his position in the sales department of the company at Tulsa.

POWER Charts Production





Like an unseen hand, power charts your production. Efficient power means high-level production. But power must be versatile if it is to be efficient. That's why International Industrial Power is "packaged" in both mobile and stationary units.

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OLD timers like Angus Crites and Fred Owen will tell you that in the days of Joaquin Murietta, the rolling hills north of Taft swarmed with wild animals of all kinds. Great herds of elk browsed on the sweet grasses that grew in abundance, occasionally stopping their browsing just long enough to move into the villages and install new lodges, of which elk are inordinately fond. All this, of course, was before the petrolic adventures came and before the walking beams had begun to creak their symphony of discontent. All this, my children, was many moons ago.

Things are different today! The elk are gone but the hills remain. The lush grasses have succumbed to the hydrocarbon treatment and the good earth has been punctured so often it resembles a Swiss chees. Wild life still swarms over Elk Hills, but it is not the same kind of wild life—it is wild about altogether different things, which, at no small inconvenience, we shall attempt to elucidate.

Leading the new order is Captain H. P. Stolz, erstwhile partner in the firm of Stanley and Stolz, who did an outstanding job for the Navy during the war, and is carrying on with equal competence now. Harry is a keen thinker and a lucid speaker, which he demonstrated definitely when the Congressional Naval Affairs Committee came out to the lease for an education some time ago. Most of all, Harry is a leader who has the sympathy and regard of his gang. It may be slightly exaggerated, but we have heard that when he develops a headache, every man on the lease takes an aspirin. In his spare moments he is wild about a rare species of indoor sport, known simply as "draw." This quaint pastime is apparently completely humanitarian, as we have been reliably informed that the genial Captain sometimes stays up far into the night just to feed the kitty.

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Closely allied with Captain Stolz and a man also of fine repute in western oil circles is one Commander F. G. Taves, formerly a substantial member of the highly technical Schlumberger organization. Fritz, as he is known to his intimates, is an affable individual, topped with a distinguished aura of grey. Despite the snow on the roof, however, there is no lack of warmth inside. He is easy to talk to and easy to like and has more friends up and down the coast than a Dublin sweepstakes winner. Boats are his favorite plaything and he has never understood why a captain doesn't jot down the weight of his anchor and thus avoid having to weigh it every time he leaves port.

Once associated more directly with Standard Oil Company is Lieut. John Domercq Jr., a lad who whiles away the tedium of his unoccupied hours, of which there are few, by studying the Dow Averages and other diagnostic caperings of the stock market. It is said that he can give pointers even to the experts, but unfortunately most of the experts don't need pointers nearly so much as they need retrievers. Nonetheless, John is a very useful member of this select organization.

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In every camp there is at least one shutter bug and Elk Hills is no exception. Lieut. John Stewart Hagestad, who, before the late lamented world fracas, was an active member of Union Oil Company's production staff, is such a pronounced victim of minicamania that he practically feels naked without a camera. Most people believe that exercise in the open air is essential to good health, but Stew is developing very nicely in the dark room, thank you.

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Then there is Lieut. V. H. King, the golf impresario, who used to be attached to General Petroleum Corporation. Vic is one of the most fervent divot lifters in the San Joaquin Valley, and being an engineer in all things has determined that at the apex of the swing the head of a golf club is traveling at a speed in excess of 100 miles an hour. This, for the first time, explains satisfactorily why the ball is driven so far into the ground.

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Next on our list is Lieut. E. M. Wheeler, desert Lothario and connoisseur of femininity, who once held sway with Signal Oil and Gas Company and has always contended that of two evils a fellow should choose the good looking one. Ed further contends that when you see a man washing a girl's car, they are engaged, but when you see a girl washing a man's car, they are married. All of which reminds us that if Colonel Drake were to return to earth today, the only things he'd recognize in the oil industry would be the wisecracks.

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Whereupon we switch to a discussion of the eccentricities of that erudite fellow, Lieut. J. I. Moore, a graduate of the University of Kansas, no less. Here is a lad who would rather read than eat, recalling a controversy that raged among the literati in the early eighties, namely, "Is a bookworm a guy who would rather read than eat, or a worm that would rather eat than read?" Without waiting for an answer we might say that John is distressed because in Taft there isn't a library where one can get a book that isn't fit to read.

Another of Elk Hills' students of high finance is Lieut. M. C. "Max" Eastman, a rather young looking chap but with a wealth of oil experience to his credit, nevertheless. Max is a stout believer in conservative speculation and points out that the investment broker who usually promises you a 25 per cent return on your money, never tells you what is going to become of the other 75 per cent. Max is thoroughly convinced that capital is the money you lend and labor is getting it back again.

●

Speaking of conservative speculation immediately brings to mind poker—they are so different. And speaking of poker at once recalls another of its more confirmed addicts up on the No. 1 Reserve, Lieut. John Fowler, a product of the Pike Drilling Company and a master of the national indoor pastime. Long John, as he is familiarly known, works on the theory of probabilities, but is willing to concede that in the art of assembling pertinent pasteboards in remunerative sequence a good deal depends upon a good deal. He is a life member of the Manicure Club, devoted to the improvement of hands, and has no sympathy for the kind of a guy who starts a penny ante game for the purpose of balancing his books before the auditors arrive.

●

From the Birch Oil Company came to Elk Hills Warrant Officer Gene Hancock whose greatest joy in life is to repair to his home and repair. He is one of the few men in the west who has a circular saw and all his fingers, and, having heard that the petroleum industry loses thousands of man hours every year because of short circuits, is now working to invent a long one.

●

Whence we turn to Lieut. W. H. "Bill" Stark, a former staff member of the Norwalk Gasoline Company, who believes that the capital of the United States is Palo Alto. Bill is very fond of big game hunting, especially the big game between Stanford and California—and especially if Stanford wins, but he still thinks sports are a trifle inconsistent; for example, nobody ever gets thrown out of a crap game for failing to make a pass. Going back to football again, Bill bitterly resents the oft repeated contention that the Indians were our first scalpers.

●

Another college man who is mighty proud of his Alma Mater is the well known Uclan, Lieut. M. L. "Mel" Barlow, who specializes on P. V. T. curves but is not averse upon occasion to taking a brief glimpse at other types of curves. Mel still has a sneaking suspicion that Kenny Washington was the first president of our fair country and is convinced that the Bruins have had more tough luck than any other Western Conference team. Well, there's no question that the life of the Westwood boys hasn't all been a bowl of roses.

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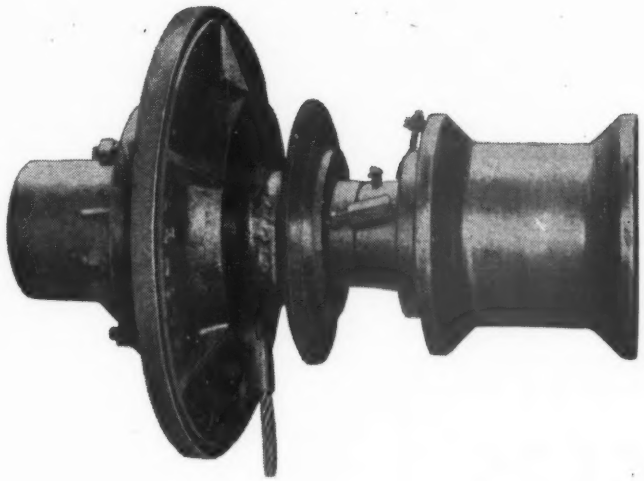
In addition to the Navy personnel there

Foster Master Breakout Cathead

(successor to Foster Hi-Speed Cathead)



SPECIAL FEATURES

Safety:

1. No Positive clutch to accidentally engage.
2. Uses two revolutions of line shaft to break joints.
3. Driller in constant control of power applied to pull line.
4. The drum has no brake, but will not crawl because it is not in contact with any moving part when clutch is disengaged.

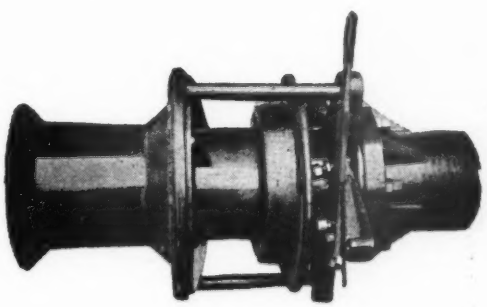
Long Life:

1. No positive clutch to disengage under load.
2. No metal-to-metal impacts or shocks.

These two outstanding Catheads, the Master Breakout and the Junior Spinning, are the result of 19 years specialization in the development of means for screwing up and unscrewing drill pipe and casing. Widespread acceptance by the industry is proof of their highly efficient performance.

Foster Junior Spinning Cathead

The Foster Junior Spinning Cathead has been thoroughly tested and approved by major operators in the United States and many foreign countries. Proven to be a remarkable saver of time, labor, and rope, it is one of the best investments that can be made in drilling equipment. It is safer, faster and more economical than the old method of spinning and tonging pipe manually.



Packed, Boxed, Weights, and Specifications for Export Shipments

	Net Gross Weight			Kilograms		Dimensions	
			Cu. Ft.	Net	Gross	Inches	Metric
JUNIOR	710	910	15.5	339.559	430.277	24½ x 26 x 42	622.301 x 660.401 x 1066.80
MASTER	600	810	18.22	272.154	362.872	28½ x 30 x 38	723.901 x 762.002 x 965.202

FOSTER CATHEAD COMPANY

BOX 1675 **WICHITA FALLS, TEXAS**

are some Standard Oilers who should be mentioned in any discourse on Elk Hills. Frinstance, there's Fred Tratt, the piscatorial exponent who once caught a fish so large that he dislocated his shoulder telling the size of it. And there's Murray Putnam, the Luther Burbank of the reservation. Believe it or not, this lad stuck a scarecrow in his garden recently that was so life-like the birds immediately began bringing back the seeds they stole last summer. Finally, there is Vic Wankowski, the big fellow with the name like a composer who is a member of the operating committee. Vic is a classic example of the well known proverb, "All work and no play makes Jack a production foreman."

Crawford tank expands

Expansion in organization, personnel, and service facilities has been announced by the Crawford Tank and Supply Company from their general offices in Dallas, Texas. E. Lloyd Byer, the new head of Crawford, in outlining the company's expansion program stated it was designed to keep pace with postwar reconversion and expansion policies of the oil and allied industries Crawford serves.

"Wider, more complete stocks of equipment situated strategically for quick, lower cost handling and distribution have already been accomplished and are to be carried out even further," the company president said.

The Crawford Company at present is supplying both bolted and welded steel tanks, prefabricated steel buildings, steel derricks, separators, and heaters.

J. E. Hobson, Crawford Tank's representative at Odessa, Texas, the last 2 years, succeeds Byer as vice president. The new executives are well-known figures throughout the oil-producing regions, both having represented the Parkersburg Rig and Reel Company, beginning with the boom days at Okmulgee in 1919, and later the Crawford Tank and Supply Company.

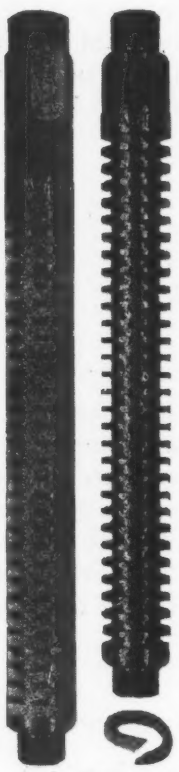
At this time, Hobson announces some of the managers and representatives in the expansion program, as follows: At Houston, E. G. Murphy, M. A. Lamkin, and O. R. Pickering; at Dallas, L. V. Gibson and C. A. Gilson; at Fort Worth, A. F. Nixon; at Corpus Christi, Ivan Cash and Edward Breedlove; at Odessa, Texas, P. P. Shaw; at LaFayette, Louisiana, G. C. McClatchey; at New Orleans, Louisiana, J. M. Morlan; at Laurel, Mississippi, Edward Miller; at Tulsa, Oklahoma, G. G. Byer; at Hobbs, New Mexico, R. G. Brasher; and at Great Bend, Kansas, E. E. McDonald.

Why Pay Penalty To SALT WATER and ABRASIVES?

MARTIN PLUNGERS

Run 3 to 10 Times Longer

Most pumping troubles are due to salt water and abrasives. Martin Plungers have solved this problem on hundreds of wells under all field conditions. They are made to fit all types and sizes of Rod and Insert Pumps.



Patent No. RE-20574

FEATURES

- Correctly engineered for handling the high lifting pressure in oil wells.
- Grooved, one-piece body, fluid-proof, rigid, durable.
- Uniform ring performance and maximum ring life obtained by controlled cross-sections.
- Split rings are easily replaced.
- Rings take the wear.
- Pump tubes last longer.

Sold Only Through Supply Stores

Write for Illustrated Folder

See Pg. 1799 Composite Catalog

FIELD REPRESENTATIVES

TOM HULETT, El Dorado, Ark.
A. W. BRANSCUM, Tulsa, Oklahoma
C. J. BAETEN, Wichita, Kansas
F. M. WILSON, Wichita Falls, Texas
MRS. LYNN HOLLOWAY, Houston, Texas
J. WALTER WADE, Chicago, Illinois
E. C. DILGARDE, Casper, Wyoming

JOHN N. MARTIN
Manufacturer
11 W. Brady St. Tulsa, Okla.

Pranger sales manager

Al Pranger, major, CWS, inactive, has returned to active duty as sales manager of The Guiberson Corporation, Dallas, Texas, after 3 years with the armed forces, according to an announcement by W. W. Finlay, executive vice president and general manager of the company. Pranger will direct the sales of Guiberson oil field tools, domestic oil heaters, steel cabinets, sheet metal products, and molded rubber products.

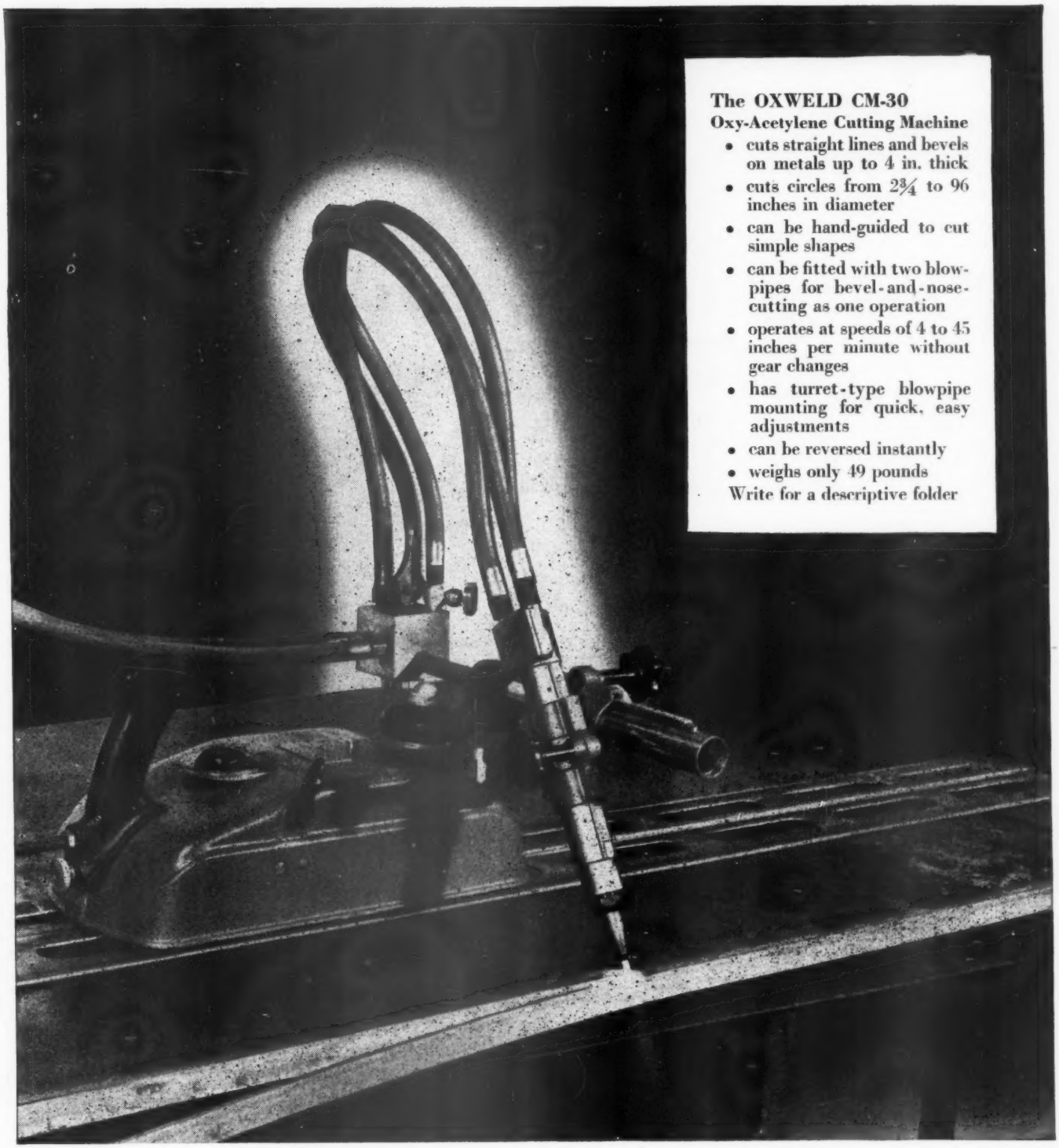
Al Pranger

For 7 years prior to going into the army, Pranger served as chief engineer and sales manager of The Guiberson Corporation. A graduate mechanical engineer of Amsterdam, Holland, he has had many years' experience in the petroleum industry.

Scouts book out

Year book for 1945, "Oil and Gas Field Development in the United States 1944" has been released by the National Oil Scouts and Land Men's Association, Austin, Texas. The volume was edited under the direction of Howard R. Brooks, chief scout of Magnolia Petroleum Company, Dallas. E. J. Raisch is assistant editor. This is the 15th annual review by the scouts of geological and geophysical prospecting, land and leasing activities, wildcat exploration, proved field development, oil and gas production, pipe line and refinery statistics. The collection of reports from all oil-producing states covers 926 pages, the largest book yet published by the association.

YOU CAN FLAME-CUT STEEL... FAST, PROFITABLY ...WITH THIS LOW-PRICED PORTABLE MACHINE



The OXWELD CM-30
Oxy-Acetylene Cutting Machine

- cuts straight lines and bevels on metals up to 4 in. thick
- cuts circles from 2¾ to 96 inches in diameter
- can be hand-guided to cut simple shapes
- can be fitted with two blowpipes for bevel-and-nose-cutting as one operation
- operates at speeds of 4 to 45 inches per minute without gear changes
- has turret-type blowpipe mounting for quick, easy adjustments
- can be reversed instantly
- weighs only 49 pounds

Write for a descriptive folder

BUY AND HOLD UNITED STATES VICTORY BONDS AND STAMPS

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

The word "Oxweld" is a registered trade-mark of Union Carbide and Carbon Corporation.

Byron Jackson officials make trip to Europe

Robert Harcus | O. W. Morgan | Lynn Sawyer

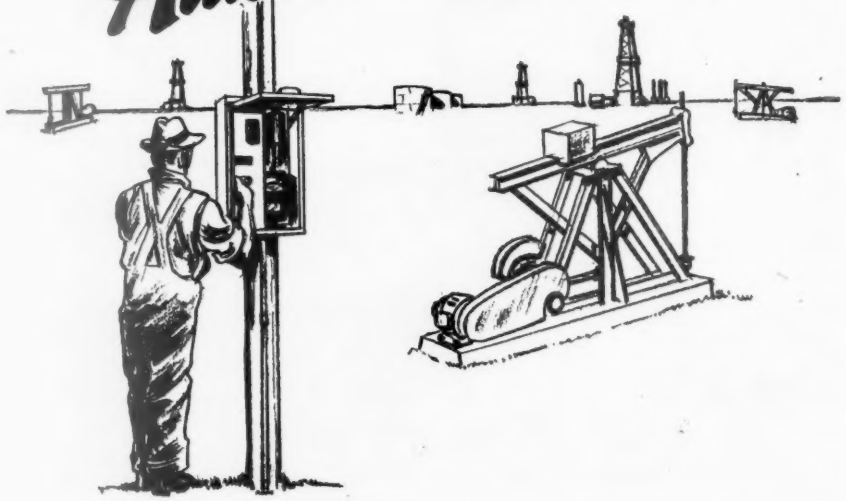
Lynn Sawyer, vice president and general manager of the pump division of Byron Jackson Company, Los Angeles, accompanied by O. W. Morgan, sales manager, oil tool division, and Robert Harcus, foreign representative, left La Guardia Field, New York, on November 20, via Pan American Airways, for an extended visit in England and the continent.

The purpose of their visit is to consult with hydraulic and petroleum engineers in England, France, Belgium, and the Netherlands concerning future requirements for centrifugal pumps, submersible motors, oil well drilling and production tools.

Sawyer enjoys a wide acquaintance in the British Isles and on the continent, having previously spent considerable time in Europe for Byron Jackson Company. Morgan was export sales manager before assuming sales management of the oil tool division, and Harcus is a native of Glasgow, Scotland, and formerly field manager of the British Burmah Oil Company in India.

NEMCO OIL FIELD TYPE

Automatic Motor Starter



The NEMCO Type D Motor Starter was designed for oil field use, where a dependable starter for pumping service is required.

Oil wells can be started and stopped intermittently. This operation is made automatic by a simple adjustment of the time clock to start and stop wells as desired. Start-Stop riders can be changed without exposure to live contacts.

Rugged W. P. Enclosure, approved Safety Switch, Heavy Duty Starter, Time Clock, Lightning Arrester, equipped with all safety features. Prices and full information furnished on request, ask for BULLETIN No. 500-1.

NELSON ELECTRIC MANUFACTURING CO.

217 North Detroit — TULSA, OKLAHOMA — Telephone 2-5131

MANUFACTURERS OF:

Explosion Resisting Motor Controls
Junction Boxes and Enclosures
Circuit Breakers and Lighting Panels
Oil Field Motor Controls
Automatic Pipe Line Sampling Devices
Cathodic Protection Equipment
Switchboards
Instrument and Control Panels
Unit Substations

A.T.A. vice president

A. E. Cudlipp, vice president, Lufkin Foundry and Machine Company, Lufkin, Texas, and president of the Texas Motor Transportation Association, was elected vice president of American Trucking Association for Texas, at a meeting of TMTA directors in Fort Worth recently. The annual meeting of the American Trucking Association will be held in Cincinnati January 12-16.

The Texas Motor Transportation Association is the state affiliate of the American Trucking Association and is composed of all types of motor carriers, such as private carriers, common carriers, and certificated carriers of all kinds.

Cudlipp is serving his third term as president of Texas Motor Transportation Association.

Returns to Bettis

W. N. (Bill) Bitterman has returned to the Bettis Sales Company as service manager after 3½ years with the armed forces. He was a navigator with the 15th Air Force and saw service in the Italian campaign. Before entering the service, Bitterman was manager of the Bettis store in Lafayette, Louisiana. He now is stationed at Houston, Texas.

Sales representative

C. Earle Stewart of Williamstown, West Virginia, has been appointed drill sales representative, according to an announcement made by Bucyrus-Erie Company, South Milwaukee, Wisconsin. Stewart will assist H. C. Neely, drill sales representative for the Evansville, Indiana, sales district, in serving central, south central, and southeastern states. He will make his headquarters at the company's Evansville office.

Metal to Metal Seal *means* Greater Security

TYPE
"4M" - "6M" - "9M" - "15M"

RECTORHEAD

That there is real value in simplicity is proved by the speed and ease with which this casing head can be set. After pipe is cemented, the lower (split) ring is welded into place, pipe cut and the upper (solid) ring welded to casing. Both rings are allowed to "float" during welding, thus assuring a stress-free weld. This style hanger is being successfully welded to any grade pipe. NO SPECIAL SKILL OR EQUIPMENT IS REQUIRED TO MAKE THE WELD, IF THE WELDER FOLLOWS THE SIMPLE INSTRUCTIONS ACCOMPANYING EACH HEAD.

The RECTOR method of welding casing suspension has been proved by thousands of field applications. This all metal RECTORHEAD with double weld, is a compact, safe, trouble-free surface hook-up that will give you long, efficient service.

By eliminating soft packing between tubing and casing, this Tubing Head eliminates many of the well operating problems caused by equalization of pressure. Seal between strings is effected solely by the standard API ring gasket, the most efficient means yet devised for any well pressures, giving the operator complete assurance of a positive shut-off between strings for the life of the well.

When you hook-up your wells . . .
use RECTORHEAD . . .
"Successor to the Bradenhead"

Available with FLANGED or SCREWED OUTLETS

This assembly is available in 1000, 2000, 3000, and 5000 pound working pressures with 400, 600, 900, and 1500 series API flanges. All casing heads regularly furnished with 2" screwed side outlets. On tubing heads either flanged or screwed outlets are available on any series.

RECTOR
WELL EQUIPMENT CO. INC.
FORT WORTH, TEXAS

Export: Lucey Export Corp., Woolworth Bldg., N. Y. C.
Representatives in all active fields.

RECTORHEAD

MAKING THE OIL INDUSTRY SAFER!

Running Tour WITH MEN IN THE INDUSTRY

● **Dr. J. T. Rettaliata,** nationally known steam and gas turbine authority who recently accepted the post of director of the mechanical engineering department at the Illinois Institute of Technology, will continue his Allis-Chalmers association as consultant on gas turbine development and similar problems, according to R. C. Allen, Allis-Chalmers steam turbine department manager.

● **Commander George Gellhorn,** who left Worthington Pump and Machinery Corporation on January 1, 1942, for active duty in the U. S. Navy, has been released to inactive status and has returned to resume his position as export manager with offices at Worthington's Harrison works. During his term of duty he was assistant naval attache in Buenos Aires, executive officer at the U. S. Naval Base in Bahia, Brazil, executive officer aboard the USS Albermarle, and navigating officer of the USS Gambier Bay. Before receiving his orders to report for active duty, Gellhorn had been in the service of Worthington for more than 11 years.

● **Walter F. Rogers,** chemical engineer of the Houston Laboratory of Gulf Oil Corporation, recently returned from Venezuela where he made a survey of pipe lines and tank farms of Mene Grande Oil Company, Gulf subsidiary, for the purpose of applying electrical protection to stop corrosion of that equipment. While in Eastern Venezuela he made his headquarters at San Tome and while in Western Venezuela at Maracaibo. He was gone six weeks and was in Caracas during the Venezuelan revolution.

● **Miller W. Conn** has resumed his duties as manager of the Perco Division, Chemical Products Department, Phillips Petroleum Company, Bartlesville, Oklahoma, after 2½ years service with the Naval Air Forces. Commissioned a lieutenant in the U. S. Naval Reserves, he has seen active service in 4 continental Naval Air Stations and for 11 months was attached to the Air Forces, U. S. Atlantic Fleet, Trinidad, B.W.I.

M. W. Conn

A. E. Buell, who has been serving as acting manager of the Perco Division during Conn's absence, will again act as Special Products Division manager.

● **Dr. Ivy Parker,** chemist at the Old Ocean Refinery of J. S. Abercrombie Company and Harrison Oil Company, Sweeny, Texas, has accepted a position in the research department of the Plantation Pipe Line Company. She will make her headquarters at Atlanta, Georgia.

● **Chester M. Gardiner,** petroleum geologist and valuation engineer, has announced the removal of his offices to 110 Emporium Building, 133 East Philadelphia Street, Whittier, California.

● **W. T. "Walt" Caldwell** and **A. W. "Al" Braithwaite,** long-time employes of the Geo. E. Failing Supply Company, Enid, Okla., and Houston, Texas, have

W. T. Caldwell

A. W. Braithwaite

announced their resignations. They have formed a partnership as core drilling contractors and have purchased two Failing 1500 drills. Caldwell who was plant manager at Enid has been in the service of the Geo. E. Failing Company for 21 years. Braithwaite was with the company for 13 years as field engineer. Office of the company will be at Enid.

● **William T. Nightingale,** Rock Springs, Wyoming, has been named general manager of production, transmission, and exploration, of the Mountain Fuel Supply Company. Nightingale, who has been with the company since its organization in 1929, was formerly in charge of lands and geology. He was made a vice president in 1940 and elected to the board of directors in 1942. He has been active in geological work in the Rocky Mountain area with The Ohio Oil Company and Mountain Fuel Supply Company since 1926.

● **F. B. Bimel** has been elected chairman of the board, and **Philo Maier,** president, of the International Petroleum Company, Ltd. Both offices formerly were held by the late R. V. LeSeuer. At the same time, **Paul Lambright** and **B. A. Myers** were elected vice presidents.

● **D. L. Hooker** has been appointed vice chairman of the manufacturing committee of the Socony-Vacuum Oil Company, Inc., **George S. Dunham,** manager of the refinery engineering department, will represent the midwest refineries on the committee. Other appointments announced by **Clark S. Teitsworth,** chairman of the committee, are those of **J. B. Middleton** to the manufacturing committee as manager of foreign refinery operations, and **S. D. Dalton** as chief refinery engineer.

● **C. H. Zachry,** president of Southern Union Gas Company, Dallas, Texas, has announced that the company's board of directors recently elected **Scott Hughes,** Dallas, vice president, and **Willie L. Lea, Jr.,** Dallas, general attorney. Hughes, formerly general attorney of the company and for the last 3 years on leave of absence serving as a major in the Army Air Corps, was released from active duty in September of this year. He has been associated with Southern Union 14 years. Lea has been a member of the company's legal department since 1936, is assistant secretary of Southern Union, and is a member of the Dallas and American Bar Associations.

Other officers of the company are Wofford Cain, chairman of the board, Dallas; James C. Reid, vice president-operating manager, Dallas; J. R. Cole, vice president, Santa Fe, New Mexico; Ross Byron, vice president, Chicago; H. V. McConkey, secretary-treasurer, Dallas; J. Glenn Turner, general counsel, Dallas; Ethel Johnson, assistant secretary, Dallas; and F. D. Bradley, assistant treasurer, Dallas.

● **Franklin Courtney Ellis,** formerly head of the public information department for Eastman Kodak, has joined the public relations staff of Standard Oil Company (Indiana), as assistant director. Ellis is a graduate of Princeton University and served on the staffs of the *Philadelphia Public Ledger,* the *Springfield (Mass.) Republican,* the *New York Evening Post,* and the *Outlook.* Standard also has appointed **John Canning** its press representative in recognition of achievements in 10 years as an assistant in public relations. Canning, an alumnus of Grinnell and Northwestern, formerly served with the Associated Press and several Iowa newspapers and radio stations. He is vice president of the Chicago Public Relations Clinic.

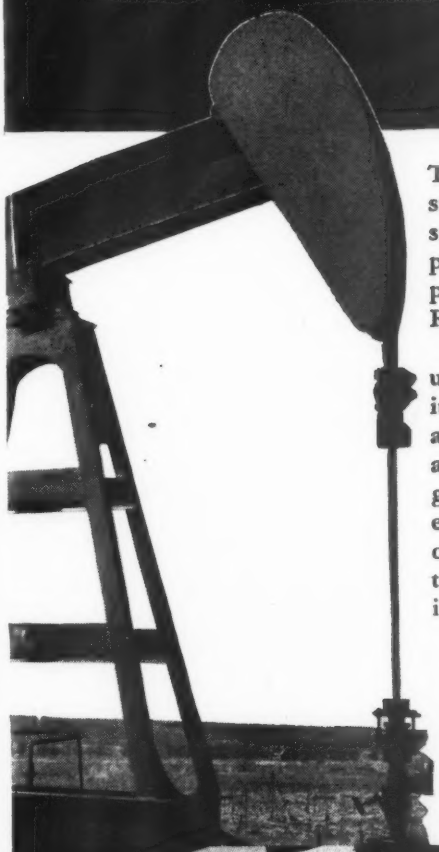
● **Firman G. Hoyt,** salesman for the last 6 years at the Los Angeles branch of John A. Roebling's Sons Company, has been promoted to the position of product sales manager of the Woven Wire Fabrics Division of the company at Trenton, New Jersey. He succeeds **W. K. Paff,** retiring after 50 years' service with the company.

F. G. Hoyt

● **Comm. A. Ernest MacGee,** officer in charge of the chemistry section of the research and standards branch of the U. S. Navy Bureau of Ships during the war, has returned to the Skelly Oil Company as solvents department head.

For Maximum Pumping Service

ROLLER CHAIN REDUCERS GIVE LONG-LIFE DEPENDABILITY

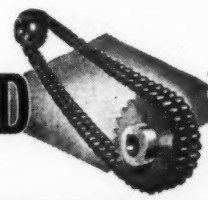


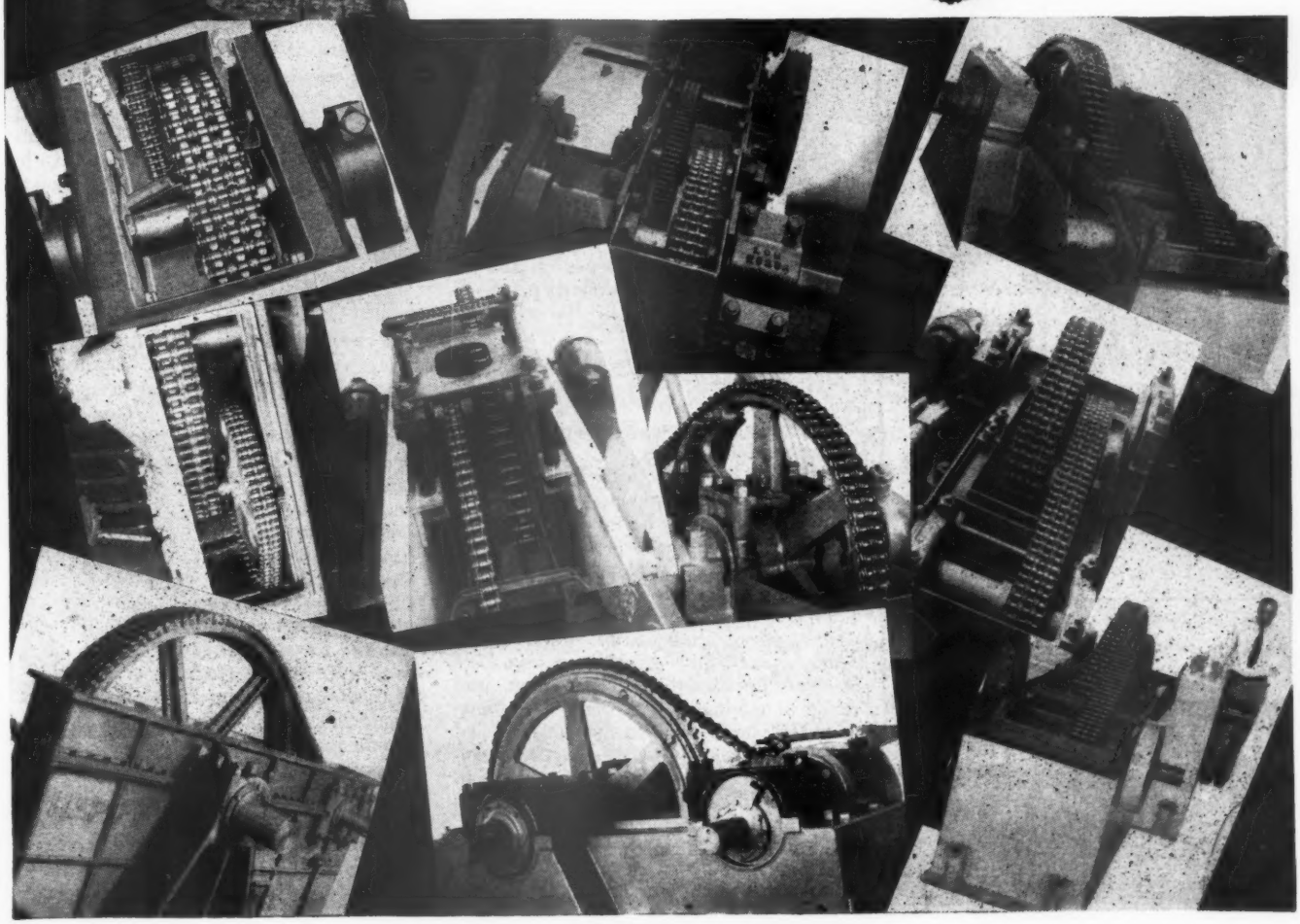
To save labor—to eliminate needless supervision and maintenance—to be sure of maximum steady output—experienced engineers and builders of pumping unit reducers use Diamond Roller Chains.

Some of the reasons for the wide usage are:—flexibility and adaptability which allow placing of the driving and driven shafts where good design and practical manufacture dictate—great reserve strength and inherent elasticity to withstand long, continuous operation and peak loading—extreme accuracy—absence of separating force, minimizing shaft bearing pressure and wear—and, the saving in power due to the high (98-99%) efficiency.

There is no record that any of the many thousands of Diamond Roller Chains in pumper service, installed in accordance with API Standard 11-E-1, have ever worn out.

"Are the Drives Equipped with Diamond Chains?" is a good question to ask when considering your next pumping, servicing, and drilling units. DIAMOND CHAIN & MFG. CO., 441 Kentucky Avenue, Indianapolis 7, Indiana. Tulsa Office 2238 Terwilleger Blvd.

DIAMOND  **ROLLER CHAINS**



ORBIT VALVES

FRICTION FREE

The Orbit Venturi Type Valve not only prevents turbulence thus prolonging the life of your tree.... But with its hardfaced seats coupled with other revolutionary operating principles combine to give the user ease of operation at 3000 to 5000 lbs. W. P. that is attainable in conventional valves at static pressure only.

ORBIT VENTURI TYPE VALVE

AVAILABLE AT YOUR FAVORITE SUPPLY STORE OR CHRISTMAS TREE FABRICATOR.

Orbit Valves Require No Lubrication to Effect a Seal.

See Pages 2194 to 2211 In 1944 Composite Catalog

ORBIT VALVE COMPANY

TULSA, OKLAHOMA

● **Capt. F. V. Lowden,** recently released from the U. S. Coast Guard Reserve, has been named veterans' coordinator of Standard Oil Company (New Jersey) and its affiliates. He will be responsible for implementing the company's policy of reinstatement of returned veteran-employes. A member of the legal department of the company since 1920, Captain Lowden returns after 42 months in the U. S. Coast Guard where he was in charge of port security for the third naval district.

● **Chester A. Baird** has been appointed resident manager of the Venezuelan Atlantic Refining Company, it is announced by W. M. O'Connor, vice president of the company. He will assume this post shortly after the first of the year and will be stationed in Caracas, in complete charge of the company's activities in Venezuela.

Baird is a native of Columbus, Ohio, and is a graduate of Ohio State University. He has been active in the oil industry for many years. From 1925 to 1944 he was with various subsidiaries of the Gulf Oil Corporation, and served as executive assistant to the president of the Mene Grande Oil Company in Venezuela the last 4 years of that period.

● **K. S. Adams,** president of Phillips Petroleum Company, has announced the appointment of **Ross W. Thomas** as executive assistant to **G. G. Oberfell** with

R. W. Thomas

G. R. Benz

the title of manager of research and development. **George R. Benz** succeeds Thomas as manager of the chemical products department.

According to G. G. Oberfell, vice president, the creation of the new position represents further management recognition of the growing importance of petroleum chemicals.

Thomas has been with Phillips since 1926. Beginning as construction superintendent, he later became research engineer on liquefied petroleum gases, working on the development of manufacturing processes and equipment for the transportation, storage, and consumption of these gases. Following a year as assistant director of research, he was appointed vice president and general manager of Philgas Company, a subsidiary formed to market liquefied petroleum gas. Subsequently the chemical products department was set up to include Philgas, special chemical petroleum products, the licensing of processes, and supplying of engineering information.

Since July, 1940, Thomas has also been president of Hycar Chemical Company, the affiliate jointly owned by Phillips Petroleum Company and the B. F. Goodrich Company to manufacture and market synthetic rubber.

Benz started with Phillips in 1925 in the engineering department. In 1927 he became interested in liquefied petroleum gas and in 1928 was transferred to the Detroit office as sales engineer, later becoming Philgas industrial division manager and assistant to the manager of the Philgas division. In 1940 he was made assistant manager of the chemical products department with headquarters in Bartlesville, holding this position until his advancement to manager.

● **James E. Sweeney,** Kropp Forge Company's new general sales manager, has a long and interesting industrial background. Completing his economic and engineering education at Niagara University, he spent the next 15 years in engineering work, several years with Sanderson and Porter. In 1931 he entered the sales engineering field, representing the Kropp Forge Company, Wyckhoff Drawn Steel Company, and Granite City Steel Company, serving them in the territory of Indiana, Ohio, and Kentucky until Pearl Harbor.

At the beginning of the war, the Kropp Forge Company called upon Sweeney to serve as works manager where his knowledge of forging application and production served the interest of Kropp customers. Now armed with an even broader knowledge of forging practice and production, Sweeney is unusually well qualified to serve in the capacity of vice president and general sales manager.

● **Colin M. Stewart** has been appointed general manager of Compania Goodrich Cubana, S. A. Havana, Cuba, it is announced by **Russell F. Moody,** vice president of the Cuban company. Compania Goodrich Cubana is associated with The B. F. Goodrich Company in the manufacture of tires, tubes, and other rubber products in Cuba.

● **Earl R. Jukes** has returned to the Cardwell Manufacturing Company, Inc., after 3 years overseas as a major in the Army Air Forces. Jukes has been reassigned to his prewar position as Cardwell sales representative in Illinois, Indiana, Kentucky, and Ohio.

Earl R. Jukes

While overseas Jukes served as director of material and as executive to the chief of staff for material and maintenance, First Air Division, Eighth Air Force. Jukes has resumed his former office address at 3524 Washington Avenue, Evansville, Indiana, and has established a second headquarters at McLeansboro, Illinois, in care of Cardwell parts and service.

● **Albert G. Loomis**, who resigned from his position as associate director with Shell Development Company to become associated with Keplinger and Wanenmacher of Tulsa. had his early training at the University of Missouri, and did graduate work at the University of California. He has taught physical chemistry at Missouri, Illinois, and George Washington and was with the U. S. Bureau of Mines both in Washington, D. C., and in Pittsburgh, Pennsylvania, then Senior Fellow at the Mellon Institute and chief chemist with the Gulf Research and Development Corporation. For the last 10 years he has been in charge of petroleum production research for the Shell Group in the United States.

Albert G. Loomis

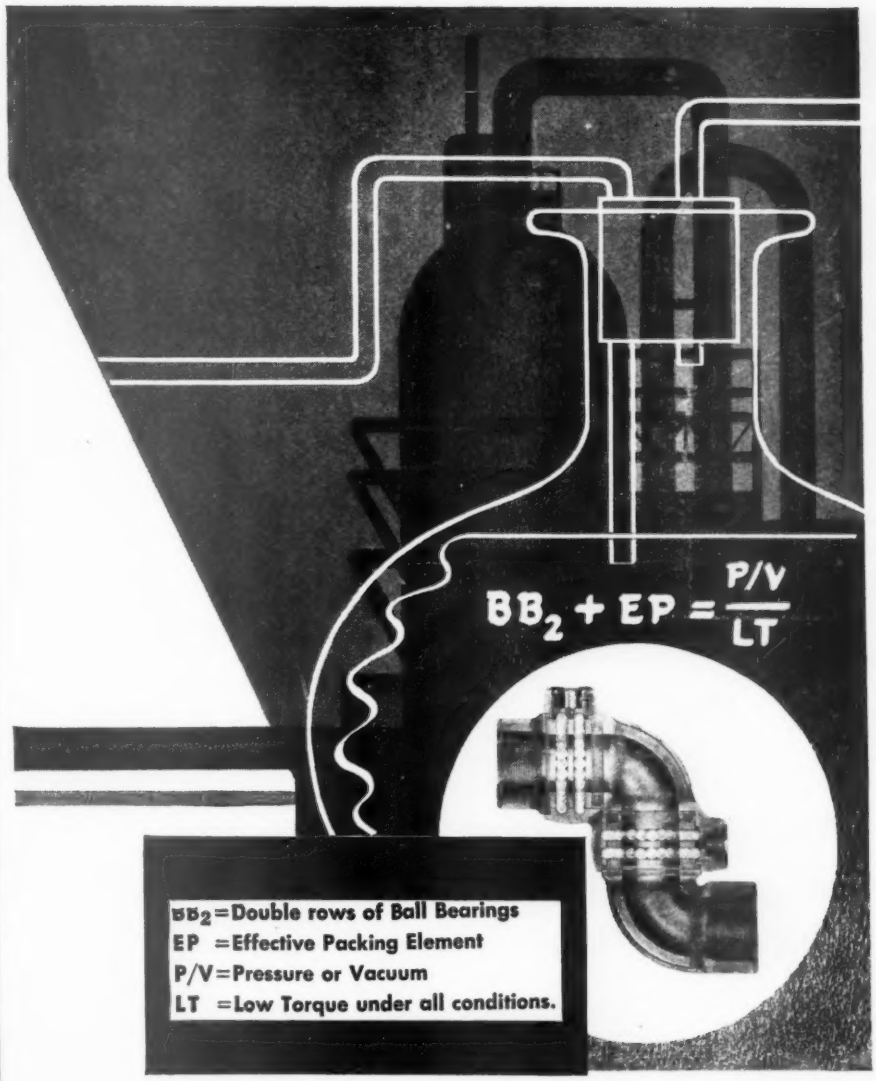
● **J. Joseph Kelleher** has been appointed manager of the contractors' division, explosives department, Hercules Powder Company. He has been a special representative of the department for several years. The division was organized in 1928 to assist contractors on large construction projects requiring the use of explosives. Kelleher joined the Hercules explosives department in 1929, and has been associated mainly with the contractors' division since.

● **L. M. Giannini**, president of Bank of America, recently announced the appointment of **Howard C. Pyle** as vice president of the bank in charge of the institution's new oil division.

Howard C. Pyle

Pyle, with a bachelor of science degree from University of California, and master of science and petroleum engineer degrees from University of Southern California, began his practical experience with the Union Oil Company of California, serving that concern 14 years, first as geologist and engineer and then as chief production engineer. He left Union Oil in January, 1943, to enter the U. S. Army as petroleum engineer, with the rank of captain, in the Washington, D. C., office of the chief engineer. Soon he was promoted to Chief, Oil Supply Rehabilitation and Development Branch of the Quartermaster General's office, with the rank of major.

In January, 1944, he was assigned to the general staff of Supreme Commander Eisenhower in the European Theater of Operations as petroleum officer. During the latter part of pre-invasion planning and during the period Field Marshal Montgomery commanded all Normandy invasion troops Pyle was loaned by General Eisenhower to serve on Montgomery's general staff.


$BB_2 + EP = \frac{P/V}{LT}$
BB_2 = Double rows of Ball Bearings
EP = Effective Packing Element
P/V = Pressure or Vacuum
LT = Low Torque under all conditions.

CHIKSAN FORMULA for PERFECT FLEXIBILITY

meets Chemical Industry's demands...

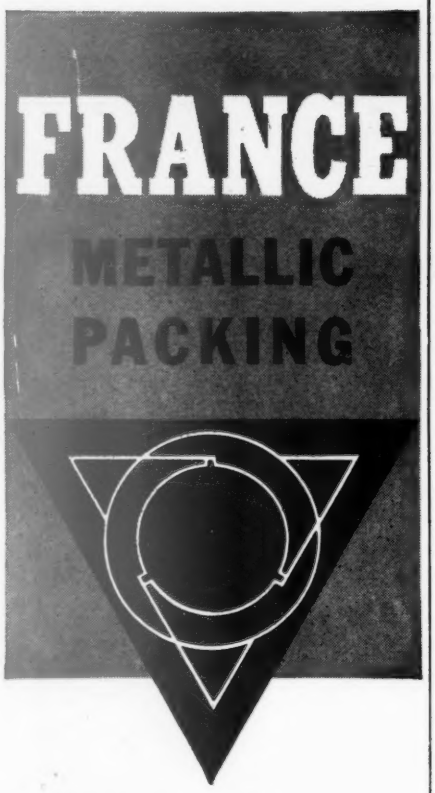
CHIKSAN *Ball-Bearing* Swivels are widely used throughout the Chemical Industry on loading and unloading lines, on process equipment... in every place where perfect flexibility with low torque is required under pressure or vacuum. Built of malleable iron, steel, special alloys, bronze or aluminum, Chiksan Swivels are used on flexible lines handling acids, alkalies, gasoline, oil, steam and many other liquids, gases and vapors under pressures to 3,000 p.s.i. and varying temperatures.

The performance of Chiksan *Ball-Bearing* Swivels in the Chemical Industry under the most severe conditions proves their ability to meet *your* requirements under *your* conditions... no matter how rugged they may be. Write for Catalog.

CHIKSAN REPRESENTATIVES IN PRINCIPAL CITIES

CHIKSAN TRADE MARK REG. BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

CHIKSAN COMPANY
BREA, CALIFORNIA



Wears as long as any other working part of the engine pump or compressor

The "full-floating" principle of France Metallic Packing prevents rod scoring and provides maximum sealing efficiency under any condition of speed, pressure or temperature—saves power and prevents costly "repacking" time.

Designed for steam, air, gas and crankcase oil service—recommended and used for years, the world over — Standard Packing of the Industry.

Write for Catalog M3

FRANCE PACKING COMPANY
PHILADELPHIA 35, PA.

Representatives in Principal Cities

LAUGH WITH BARNEY

She: Will you love me when I'm old?
He: Love you? I shall idolize you, I shall worship the ground under your little feet, I shall—say, you aren't going to look like your mother, are you?

Did you have a good time the other night, Gladys?
Naw, I've got too much willpower.

The man in the restaurant was having trouble cutting his steak. Finally he called the waiter.
I can't cut this steak. Take it back and bring me another.
Sorry, sir, replied the waiter, after closely inspecting the steak, can't take it back, you bent it.

He: Will you marry me?
She: No!
And so they lived happily ever after.

In standard liquid measure, two pints make one cavort.

The barber lifted the young customer into his chair and said: How do you want your hair cut, son?
Like dad's, with a hole in the top.

"Jack is so original. He says things to me that nobody else would dream of saying."
"What has he been up to now—asking you to marry him?"

He: I just got a $5,000 check from home.
Him: Good! Now you can pay me the $5 you owe me.
He: Why don't you wait till I tell you the rest of my dream?

First G.I. Wife: Does your husband still find you entertaining?
Second G.I. Wife: Not if I can help it.

Medico: Is there any insanity among your relatives?
Private: Yes, I'm afraid there is. They keep writing me for money.

"What do you think is the cause of so many unhappy marriages?"
"Too many people marry before they have sense enough to stay single."

"Who is that man over there snapping his fingers?"
"That's a deaf mute with the hiccoughs."

"What do you mean by telling that man I was deaf and dumb?"
"I didn't say deaf!"

"Ever hear about the fellow who invented a device for looking through brick walls?"
"No, what's he call it?"
"A window, you dope!"

House Detective: Hey, you, what's the idea of swiping those towels from this hotel?
Guest: Honestly, I didn't mean to take 'em. I just needed something to wrap the silverware in.

"I was a spy."
"Did they shoot you?"
"I don't know. I was blindfolded."

Moe: A friend of mine told me I look just like you.
Joe: That so? What did you say?
Moe: What could I say? He was bigger'n me!

Prof.: Mr. Brown, allow me to present my wife to you.
Dean: Sorry, but I already have a wife.

Doctor: Nurse, how's the patient in 831?
Nurse: All right. He saw four pink elephants!
Doctor: That's odd. I saw only one!

Guide: This castle has stood for 300 years. Not a stone has been touched, nothing altered, nothing repaired or replaced.
Tourist: They must have the same kind of landlord we've got!

Hoke: How is ol' Bill these days?
Moke: Oh, he's much better since his operation!
Hoke: What operation?
Moke: Haven't you heard? They removed a brass rail that was pressing against his foot for years.

Cop: Didn't you hear me yell for you to stop?
Lady Driver: No, sir.
Cop: Didn't you hear me whistle?
Lady Driver: No, sir.
Cop: Didn't you see me signal?
Lady Driver: No, sir.
Cop: Well, I guess I'd better go home. I don't seem to be doing much good around here.

Critic: I don't think the audience who saw Hamlet last night was very educated.
Friend: Why not?
Critic: After the play was over, they yelled, "Author, author!"

First Cop: Got away, did he, the dirty crook! Did you guard all the exits?
Second Cop: Yeah, but we think he escaped out of one of the entrances!

Professor Borscht was a great hand at exploring and digging in ancient ruins. But when it came to love he was pretty awkward. One night, however, as he rested his head on his beloved's bosom, he felt impelled to express himself.
"You, know, dear, resting here like this gives me the greatest happiness. Only once before have I felt so relaxed."
"When was that?" asked the young, shy maiden.
"One night in Egypt," said Professor Borscht, "when I was camped between two pyramids."

"Still engaged to Dorothea?"
"No."
"God! How'd you get rid of her?"
"What?"
"How'd you drop the old hag?"
"I married her."

New and Improved MACHINERY AND EQUIPMENT

A REGULAR FEATURE
appearing in
THE PETROLEUM ENGINEER
700 Irwin-Keasler Bldg.
Dallas 1, Texas

(1) *Smith hole opener*

H. C. Smith Oil Tool Company, Compton, California, announces a new 6-point hole opener. The 3 rock bit gage cutters and the 3 reamer cutters maintain 6-point contact with the wall of the hole thus assuring full gage to bottom. The gage cutters are manufactured to the same specifications as the H. C. Smith Rock Bit cutters, including the triple bearing construction—an exclusive Smith development. The body is cast steel, scientifically designed and heat treated. Another important feature of the new H. C. Smith 6-point hole opener is the box connection that permits the use of any type of rock or pilot bit.

(2) *Arc-welding aid*

A new arc-welding compound designed to aid in instantaneously creating and maintaining a metallic welding arc where low currents and small-diameter electrodes are employed has been announced by the Electric Welding Division of the General Electric Company. Known as Strike-easy, this new compound is easily applied and can be used on any kind of metal with any type of electrode.

The compound, which is in paste form, is available from distributors in 1-lb. glass jars, completely ready for use. No mixing or other preparation is required.

Keep Posted On
NEW EQUIPMENT
Use Card

Advancements in petroleum and plant equipment are being made rapidly. Keep abreast by making full use of *The Petroleum Engineer's* enlarged New Equipment Section.

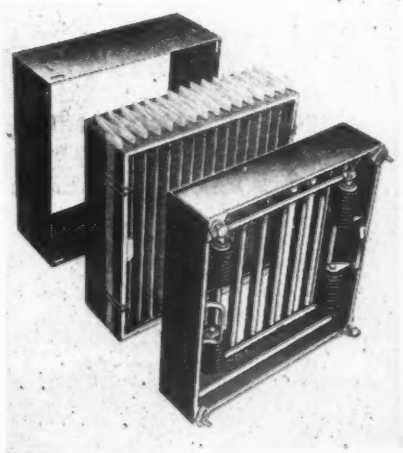
All items are numbered. A business reply card requiring no postage if mailed within the United States is provided. Check or encircle the number on the card that corresponds with the product or products in which you are interested and drop it in the mail. Literature and prices will be sent promptly on receipt of card.

(3) *Electro-Airmat*

The latest addition to the American Air Filter Company's line of electronic air filters is the Electro-Airmat in which the collector element is electrostatically charged airmat paper. Introducing an entirely new principle in electronic air filtration, the arrestance rating of the Electro-Airmat, when tested by the discoloration method, is 90 per cent or better with atmospheric dust or smoke. This efficiency is obtained at the normal velocity of 35 f.p.m. through the Airmat media and the standard rating of 1000 c.f.m. per standard-sized 24-in by 24-in. unit. The filter weighs 40 per cent less than electronic filters having metal plate collectors and requires 30 per cent less floor area.

Airmat is American Air Filter's trade name for a cellulose product composed of a number of plies of porous, tissue-like sheets formed of short cellulose fibers in "jack-straw" arrangement. When an electrostatic charge is applied to Airmat, the plies tend to separate and each individual fiber becomes a collecting electrode that attracts and holds the dust and smoke particles. Airmat is also a highly efficient mechanical filtering media; thus, when the power is off for any reason it affords ample protection against the infiltration of dust due to "stack effects" in air conditioning systems.

Ease of installation and economy and convenience of maintenance are outstanding features of the Electro-Airmat, it is stated. The full height ionizers reduce electrical losses due to fewer wire ends. The power pack operates on a 110-volt 60-cycle single-phase current. Total power consumption is approximately 220 watts at 110 volts including transformer losses in the power pack, etc. When the Airmat paper has accumulated its dust load it is removed and replaced with clean material by means of turning a crank in a mechanical loader that automatically folds the paper into the serrated base section of the filter unit. Spare cells loaded with clean Airmat can be provided.



May the Unquenchable SPIRIT OF CHRISTMAS

Bring to the hearts of mankind a sense of ineffable peace — and adamant determination that the peace be unceasingly cherished and maintained.

Then—those we love and honor have not sacrificed in vain, but gloriously live throughout all eternity.

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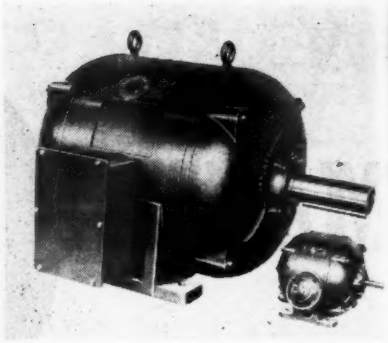
(4) *Protected-type motor*

With the addition of 3 new frame sizes, designated as B58-A, B, and C, the Crocker-Wheeler Division of Joshua Hendy Iron Works, Ampere, New Jersey, now offers a complete line of alternating-current, squirrel-cage, Protected Type Motors from 1 to 200 hp. Priced the same as the conventional open type and rated 40 C rise, full-load continuous duty, with a 15 per cent service factor, these motors provide protection against dripping liquids, falling metal chips, and other foreign matter.

Sizes built in NEMA standardized frames, 203 to 326 inclusive, have no openings in the frame or shields above the horizontal center line. NEMA standardized frames 326 to 505 as well as the 3 newly added larger sizes are basically the same in construction with the addition of two shielded air exhaust openings in the upper half of the frame. The design of these openings precludes any possibility of falling liquids, etc., entering the motor.

The company's patented centrifugal bearing seal is used in all ball-bearing machines. The seal permits the use of softer grease for better lubrication and longer bearing life, it is stated.

Alucast rotors, in which the bars, fans, and end rings are cast in one operation from aluminum alloys, is employed for sizes 203 to 404, inclusive. Rotors of larger sizes have copper bars with brazed on fans and end rings. Stator coils are protected by Vinylastic insulation.



Two extrames of Crocker-Wheeler protected type motors, the B-58 and the smallest of the line, the 203.

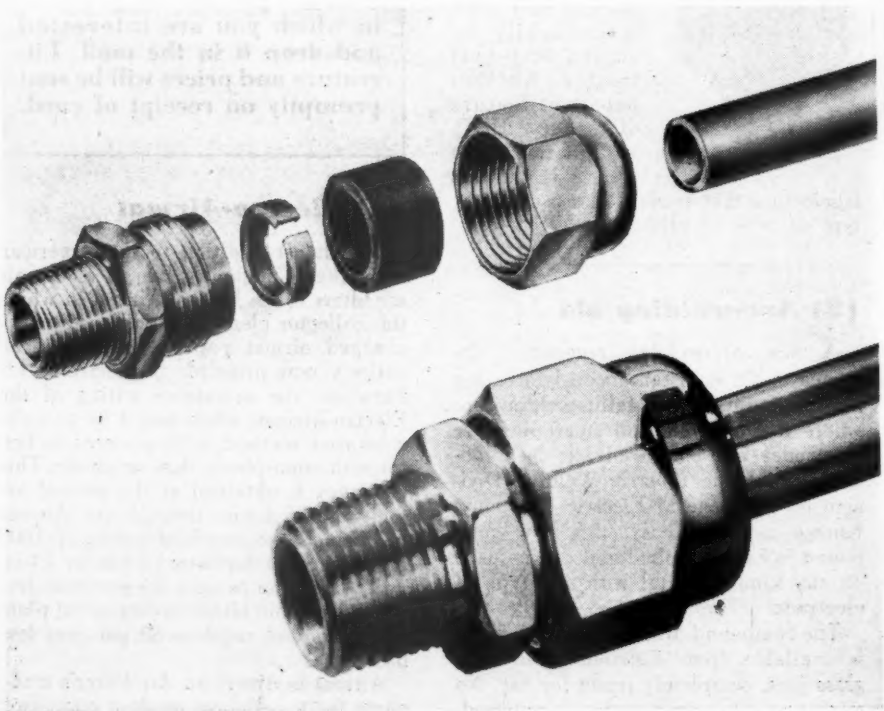
(5) *Flexigrip tubing*

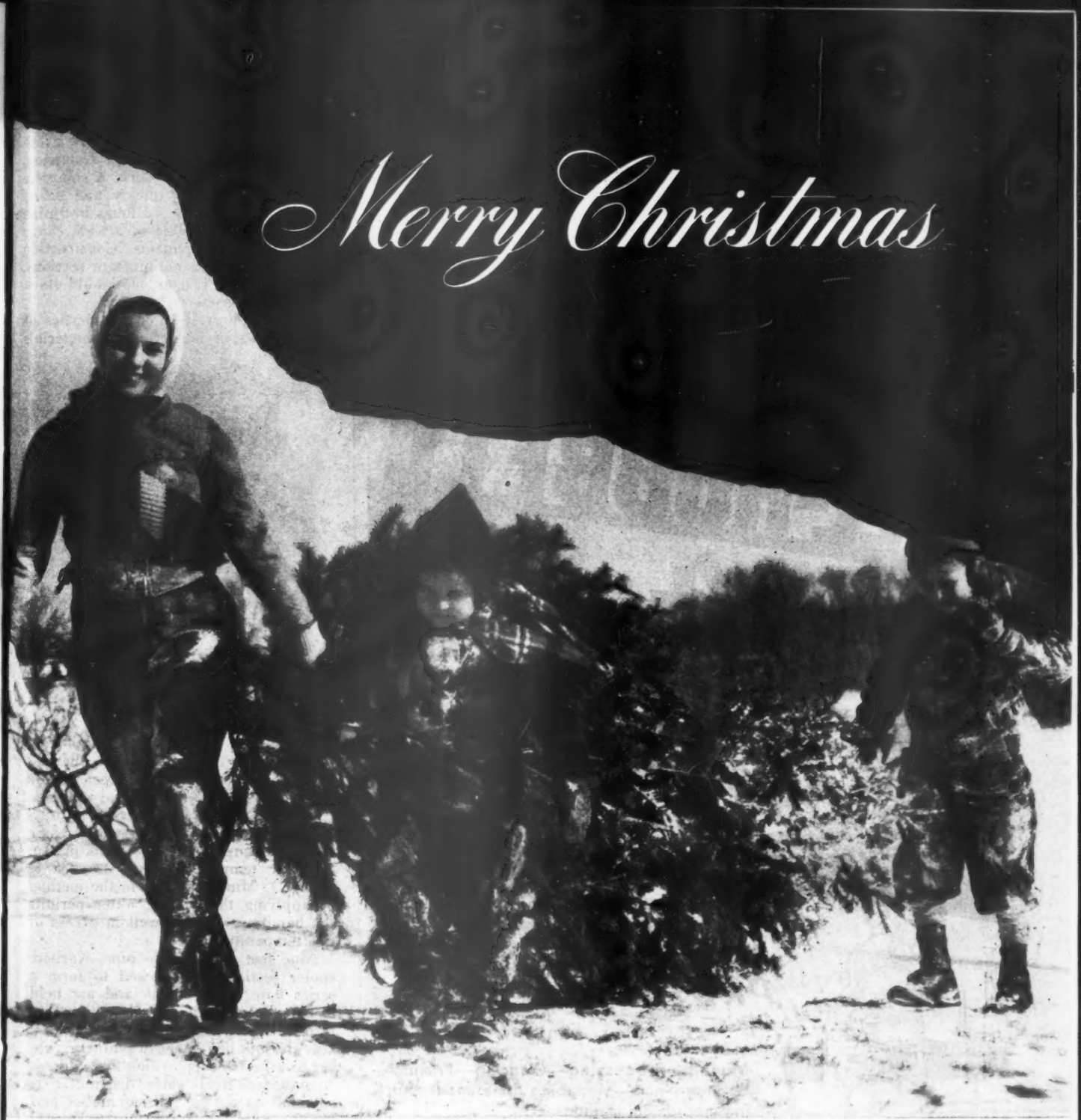
Flexigrip time saving tubing fittings that eliminate end preparation or soldering of the tubing and yet produce a stronger, leakproof and flexible joint have been announced by Gustin-Bacon Manufacturing Company of Kansas City, Missouri. The Flexigrip fitting, made in standard sizes from ⅛-in. to 1½ in. O.D., consists of 4 parts — the body, a gripping ring, synthetic rubber gasket, and nut. To attach the fitting, the nut (with gasket and ring inside) is slipped over any plain-end tube, cut to desired length. The tubing end is inserted into the body as far as it will go and the nut tightened. Tightening the nut compresses the ring into a tight grip and moulds the gasket around the ring for a leak-proof seal that is so flexible it will withstand unusual vibration or impulse.

Elimination of flaring, swedging, or soldering, the tube end adds considerably to the strength of the joint as well as saving time and labor, it is stated. Economies in time and material are also considerable over the collar, ring or ferrule type of tube-end fitting, according to the manufacturer.

Flexigrip tubing fittings are available in brass, aluminum, or steel.

"Exploded" view showing component parts of Flexigrip before assembly. Inset: Flexigrip coupling applied.





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(6) *Cleaning unit*

Oakite Products, Inc., New York, New York, has developed a new multiple duty steam cleaning unit known as the Oakite vapor cleaning unit.

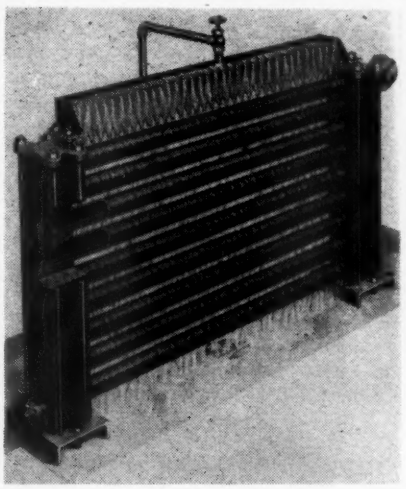
This unit is a self-contained, down-draft flame, oil-fired, enclosed coil-type steam generator that delivers hot vaporized cleaning solutions under selective pressures up to 200 lb. for the speedier, easier removal of grease, grit, grime, paint, and other deposits from surfaces, according to the manufacturer. A wide range of fuel oils such as No. 1, No. 2, or No. 3 fuel oil, kerosine or gasoline, may be used to operate the unit. Due to its flexibility of steam pressures, the unit may be used on many different types of light and heavy-duty cleaning.

Extremely rugged in construction, only the highest quality materials are used in the manufacture of the unit. Built for long, continuous, trouble-free service, the unit has tremendous reserve power and operates without vibration, it is asserted. Many new, exclusive features are incorporated that provide for simplicity and ease of operation and maintenance, rapid steam generation, unusual solution tank capacity, effective operation of two steam guns simultaneously, wide flexibility in its application to various cleaning operations, and other advantages.

(7) *Cascade cooler*

Karbate sectional cascade coolers, designed for the efficient cooling of corrosive liquids and gases, are now available from National Carbon Company, Inc., New York, New York. A complete cooler assembly is quickly and easily erected from 4 standard items in 5 pipe sizes and is adaptable to a wide range or process requirements. Construction is such that additional units, or sections, may be added just as one would stack office filing cases.

Having the well known properties of Karbate impervious graphite materials

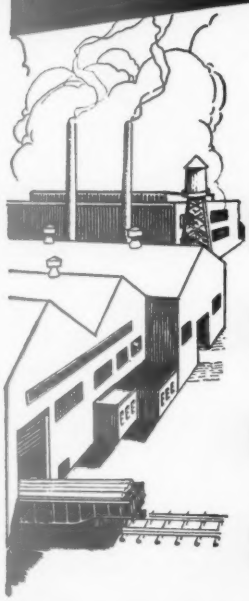


such as corrosion resistance, high heat transfer rate, resistance to thermal shock, and freedom from corrosion scale formation, Karbate sectional cascade coolers are suggested for service in practically all acids, caustics, and organic solvents at pressures up to 75 lb. per sq. in. and temperatures up to 338°F. (170°C). Minor changes in the method of applying the cooling water permits the handling of gases well in excess of this temperature.

Nine feet long, single pipe, Karbate cooler sections are stacked to form a series flow vertical bank and are held in place by steel tie rod assemblies that form a rigid supporting structure. Gaskets are supplied either in synthetic rubber or asbestos composition as required. A standard steel water distributor is mounted on the tie rod assemblies and can be adjusted accurately to assure uniform cooling water distribution over the pipe. The compact construction offers close pipe spacing and eliminates the necessity of redistribution baffles, it is stated. Maximum effective external surface areas of approximately 120 sq. ft. are available in all 5 sizes in the maximum recommended cooler height of 6 ft. The complete cooler assembly is easily dismantled for the addition or replacement of interchangeable sections.

The Geological Survey has issued a map showing structural geology of the Little Buffalo Basin oil and gas field and vicinity, Park and Hot Spring counties, Wyoming. Copies may be obtained from the Geological Survey, Washington 25, D. C.

HILL-HUBBELL
4
BASIC
ADVANTAGES
IN
MODERN FACTORY
APPLIED STEEL PIPE
PROTECTION • • • •



Machine Processing—Cleaning—Priming—Coating—and—Wrapping done under exacting mechanical methods.

Modern Line Production—all under one roof with controlled conditions, insuring prompt service with efficient workmanship.

Warranted Rail Delivery — HILL-HUBBELL mechanically processed steel pipe assures investment protection.

HILL-HUBBELL Processed Pipe—eliminates delays, saves time and labor, ready for installation upon arrival.

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ANE-WELLS ENGINEERS

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FORMULAS

To determine the best wire for the Gun Perforator

Deeper drilling, with increased subsurface temperatures and pressures has subjected Gun Perforating equipment to conditions not fully anticipated in the initial design. The insulation protecting gun and controller wiring is a vital link in the chain of features that make up a successful, selectively-fired gun. Temperatures in excess of 300° F., hydrostatic pressures as high as 5000 pounds per square inch and combustion shock are now met with minimum difficulty. Gun Wire Insulation is a small detail in Gun Perforating operations, yet Lane-Wells Engineers tested 51 insulation formulas in the Laboratory and in the field to find the best.

This is only one of many Engineering Projects being carried out regularly by laboratory, design and field engineering facilities in an effort to give *better service* to our customers. It is one reason we ask you to "Call Lane-Wells and get the job done right."

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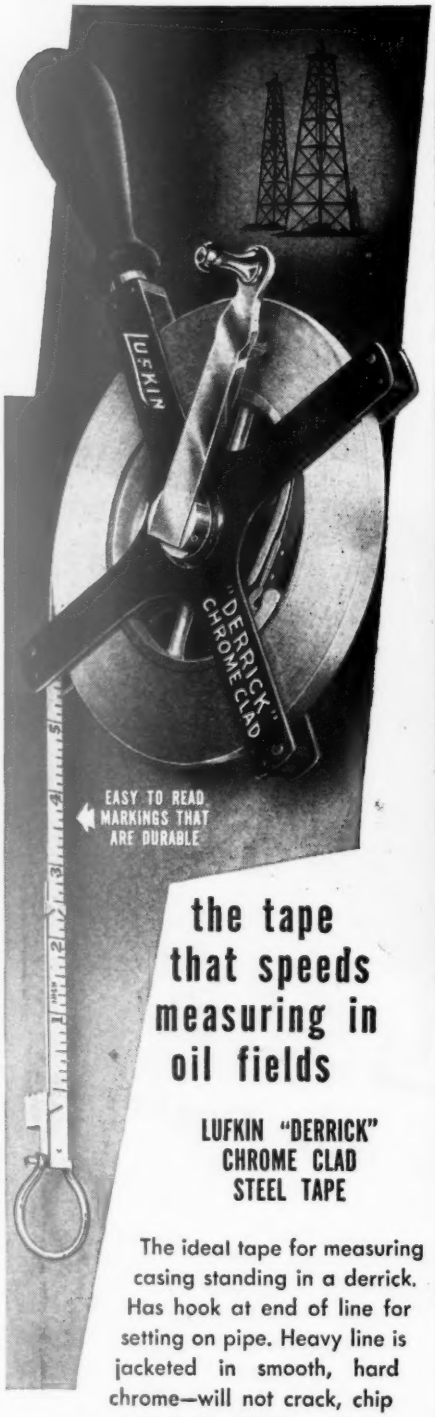


the tape that speeds measuring in oil fields

LUFKIN "DERRICK" CHROME CLAD STEEL TAPE

The ideal tape for measuring casing standing in a derrick. Has hook at end of line for setting on pipe. Heavy line is jacketed in smooth, hard chrome—will not crack, chip or peel. Jet black markings are easy to read, recessed so they can't wear out. 4-arm frame with large winding handle. Get the best—order the Lufkin "Derrick" through your supply house. For free catalog write THE LUFKIN RULE CO., SAGINAW, MICH., New York City.

LUFKIN

FOR ACCURACY

(8) *Electronic bore gage*

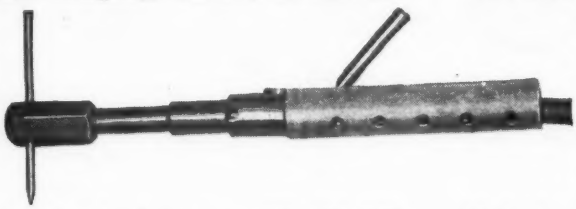
A new electronic bore gage utilizing direct contact to measure the diameter of tube, gun, and other cylindrical interiors with an accuracy of 0.00005 in., will be introduced soon by the Chrome Gauge Corporation, Philadelphia, Pennsylvania.

The new gage, comprising a projection rod mounted on a stabilized frame and containing a delicate, flexible point, is inserted into a bore where it checks by contact all interior surfaces. The results of the test are transmitted instantaneously to a Brown ElectroniK precision indicator. This instrument, featuring continuous balance, picks up and indicates various imperfections, air pockets and other unwanted conditions to 0.00005 in.

The new device, said by Chrome Gauge Corporation officials as offering 100 per cent greater accuracy, is expected to be marketed in the chemical, petroleum, metallurgical, and other industries that either manufacture or make use of tubes and pipes, and for processes where pipe and tube interior surface imperfections affect the process and product.

(9) *Carbon electrode holders*

A complete new line of air-cooled carbon electrode holders for manual welding has been announced by Tweco Products Company, Wichita, Kansas. The



line includes four sizes: 150, 200, 300, and 500-amp. models. Positive Hol-Grip design with ample length and ventilation are features of this new line.

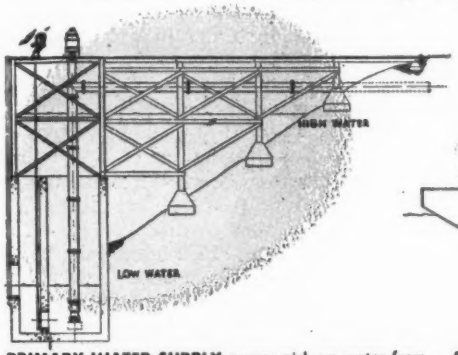
The average carbon arc welding job is done with either the 13½-oz. 150-amp. holder or the 20-oz. 200-amp. unit. These two units are supplied optionally with or without special "Quick-Attach" whip cables for short duration jobs. The 300 and 500-amp. models are suitable for heavy welding, and cutting jobs.

(10) *Internal plating for steel pipe*

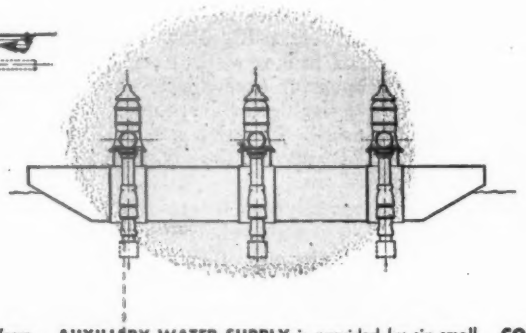
The inside of steel pipe can be electroplated with nickel or other metals by means of a new process developed by the Bart Manufacturing Company. The process is relatively inexpensive and is known as the Bart Lectro-Clad Process, it is asserted. It develops a smooth, ductile, pore-free nickel deposit fully adherent to the base metal, and it can be applied to pipe or tubing up to 18-in. overall diam., in random lengths of approximately 20 ft. Use of the Bart Lectro-Clad Process endows steel pipe with the corrosion-resistance of nickel, at the same time retaining the low cost, strength, and fabricating characteristics of the former, officials of the Bart company state.

Fittings and pipe line accessories are available for complete piping systems. Welding and fabricating techniques have been fully developed. The internally plated pipe can be welded, reduced and bent, hot or cold, without destroying any portion of the internal lining. In reducing tubing by the cold reduction method, it is now possible to predetermine the actual thickness of the plating throughout the entire reduction, because the applied metal and the base metal reduce in equal ratio.

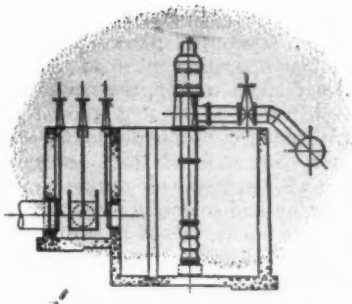
Another page from the widespread experience of Fairbanks-Morse pump engineers!



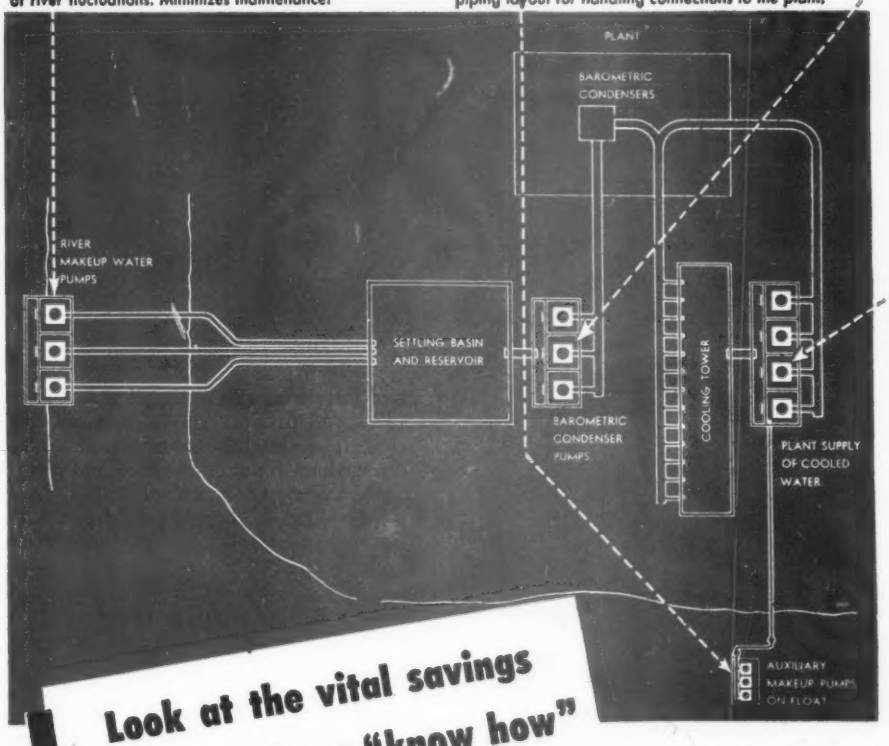
PRIMARY WATER SUPPLY pumps pick up water from low point in river where water is coolest. For same quality water, horizontal pumps would require sinking of caissons—impractical and extremely costly. Besides money-saving simplicity of F-M Pomona installation, note added advantage that pumps are below water level—always primed—and motors are above water level—always safe—regardless of river fluctuations. Minimizes maintenance!

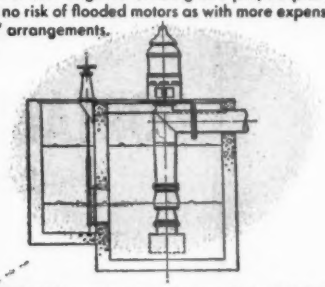


AUXILIARY WATER SUPPLY is provided by six small capacity Fairbanks-Morse Pomona Turbine Pumps mounted on floats in the river. Here, besides installation simplicity and the no-priming, protected-motor advantages outlined at left, the unusual compactness of Fairbanks-Morse Turbine Pumps made possible important savings in barge size with ample floor space between the pumps, and a very simple piping layout for handling connections to the plant.

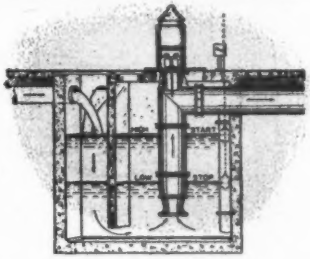


CONDENSER PUMPS are Fairbanks-Morse Mix-Flow type, giving high volume at relatively low lift. Note simplicity of installation with no costly "dry well" necessary. Also note clean, uncluttered floor space around pumps with all flow connections underground and motor heads readily accessible for servicing. No climbing into pits, no priming problems, no risk of flooded motors as with more expensive "dry well" arrangements.





PLANT SUPPLY pumping installation of the 5000 GPM units is also unusually simple, compact and inexpensive. Here again—no costly dry wells, no priming or motor-flooding problems, no complicated maintenance requirements . . . all features that save time and money!



IN ADDITION to the above pumping applications, Fairbanks-Morse Vertical Pumps also handle the drainage pumping for this plant. Two F-M Niagaras handle 20,000 GPM at 12 foot head. Though the water is sand-laden these pumps handle it in large volumes without difficulty.

Look at the vital savings Fairbanks-Morse "know how" made at this plant!

FOR a quick picture of the *multiple* savings you can make with a Fairbanks-Morse Vertical Turbine Pump installation, check over this industrial layout. It was made by Fairbanks-Morse Pomona engineers for a chemical process plant—one of the largest and most modern of its kind in the nation.

In addition to these savings which are typical of Fairbanks-Morse experienced pump engineering, note also the unusual versatility of Fairbanks-Morse Turbine Pumps. From primary water supply, through condenser pumping, plant pumping, and drainage—F-M Vertical Pumps handle each type of job with important installation, operation and maintenance savings!

No matter what your pumping application, Fairbanks-Morse experienced pump engineering is ready to help you cut installation costs, reduce operating costs and simplify pump maintenance. A call or letter to your nearby distributor places this extensive pump knowledge at your service without obligation. Fairbanks, Morse & Co., Chicago 5, Illinois.

Write for Bulletin MO-125

POMONA PUMPS

another product of

Fairbanks-Morse

A name worth remembering

Diesel Locomotives • Diesel Engines • Generators • Motors • Pumps • Scales
Magnetos • Stokers • Railroad Motor Cars and Standpipes • Farm Equipment

(11) *Excavator*

A new 1½-yard model 38-B fully convertible excavator is announced by Bucyrus-Erie Company, South Milwaukee, Wisconsin. Showing a remarkably fast operating cycle in months of thorough field testing, the new unit has demonstrated continuous record-breaking output for users, the manufacturer asserts. Selection of the most modern materials, widespread use of selective hardening and scientific weight distribution have made the 38-B amply strong for tough digging with excess weight eliminated.

In a recent extensive field test, a new Bucyrus-Erie 38-B shovel matched the cycle speed of a much smaller machine. This amazing performance of the larger machine has been attained by careful synchronization of speed and power of the various functions and excellent distribution of weight. Big ultra-responsive clutches and brakes with direct control give the operator exceedingly accurate "feel" so desirable for continuous large output. Ease of operation has much to do with 38-B speed in the digging cycle, it is pointed out.

Fundamentally constructed for equal effectiveness as a shovel, dragline, crane, or clamshell, the new 38-B offers a number of operating refinements. As a dragline, the 38-B has big working ranges with a new mast-type suspension available for long booms. Full rotating fairlead, selection of wide, long, and tapered end crawler mountings for ample bearing area and superior performance in soft going are other dragline features, it is stated.

Features of the new 38-B shovel include a strong but light boom with large diameter point sheaves for effective application of digging force, independent positive twin rope crowd, and high lip all-welded dipper for fast filling and dumping in rock or dirt.

As a crane, the 38-B offers long booms with optional jib extensions, two-clutch-operated independent boom hoist with full, accurate power control of raising

and lowering, and optional independent two-speed propel. Ample capacity, easy control of clutches, drum capacities and dimensions, balance of speed and power, accessibility of machinery, and easily mounted and demounted front ends make the new 38-B a truly convertible excavator.

(12) *New pump line*

Marco Company, Wilmington, Delaware, has placed on the market a new line of pumps that, according to the manufacturer, will handle with a minimum of vapor lock anything that can be pumped—heavy viscous materials or light volatile materials.

The pumps maintain volumetric efficiency because they are equipped with an automatic compensating wear control.

They have a positive displacement and high vacuum, it is asserted. The shafts are equipped with a self-adjusting seal enclosed in steel armor that will hold against pressure and vacuum so that there is no danger of the product being pumped becoming contaminated.

The smallest model, called the Victor, which is intended for equipment installation, needs no lubrication. The other designs, which are called the Commander and the Challenger, are equipped with automatic lubrication.

The pumps are built of stainless metal unless otherwise specified and can be taken apart easily for cleaning. As there are no pockets or threads to impede the product's being processed, the pump is unusually sanitary.

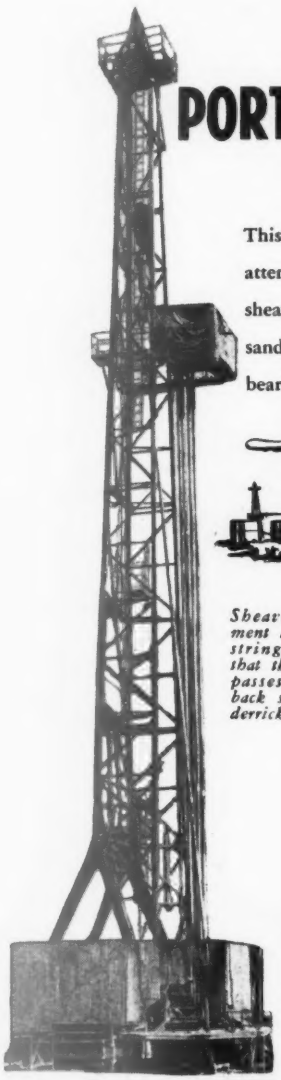
They operate under high or low pres-

REGAN

PORTABLE RIG CROWN BLOCK

200 TON CAPACITY

This newly featured portable rig crown block has attracted much attention among oil operators everywhere. It has a 48-inch fast sheave; 36-inch main sheaves; 26-inch dead line sheave; 18-inch sand and catline sheaves. This model has the regular REGAN dual bearing and Alemite lubrication.



Sheave arrangement allows the stringing up so that the deadline passes down the back side of the derrick.

CROWN BLOCKS FOR EVERY CONDITION

REGAN'S well-known line of crown blocks covers every condition encountered in any oil field. Forty-two years of experience in the construction of quality oil field equipment places the REGAN CROWN BLOCKS at the top of the equipment field.

Information will be sent on request.

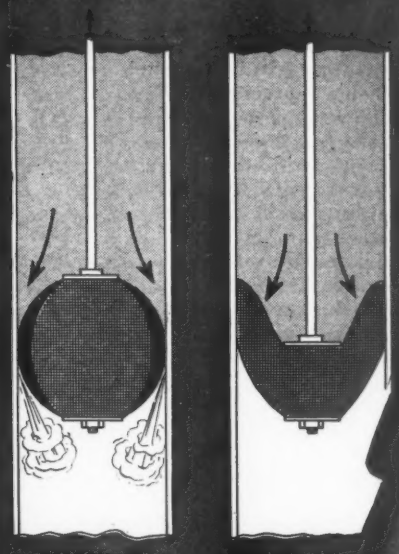
Regan FORGE & ENGINEERING CO.

GENERAL OFFICES & PLANT SAN PEDRO, CALIF.

Quality Wrought on the Forge of Experience

Mid-Continent Representatives: Mid-Continent Supply Co., Houston, Texas. New York Office: 17 Battery Place—Geo. R. Woods, Mgr.

CARRY A FULL LOAD EVERY TRIP with the *Guiberson* Basket Type Swab



WHICH way would you turn the pail? Right side up, of course. And that's just what the Guiberson flexible type fluid cup does. It turns the cup *right side up* and pulls a full load every trip. Flexible cup construction prevents wear while running in the hole. Cups are easy and quick to change. Swab falls faster than the swabbing line will unreel from the drum and gives greater fluid passage through the mandrel than any other type of swab. Available in all standard sizes of tubing and casing. Flexible basket type cups will fit slightly varying diameters of tubing and casing without loss of fluid.

The Guiberson flexible basket type swab takes up its own wear and gives complete seal. Cups are made of Guiberson's own special compound that resists abrasion and gives maximum swab life.

BETTER BE SAFE THAN SORRY GUIBERSON

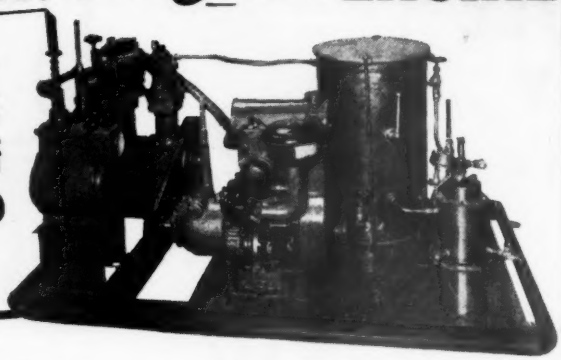
ESTABLISHED 1919

THE GUIBERSON CORPORATION

DALLAS, TEXAS

WISCONSIN Air-Cooled ENGINE

Assists in the QUANTITATIVE ANALYSIS of CASINGHEAD GAS . . .



★ The unique, skid-mounted field unit illustrated above, built by Harley Sales Company and designed by Otha H. Grimes, a prominent gasoline manufacturer of Tulsa, Okla., was developed for the highly specialized function of making accurate quantitative analyses of casinghead gas. This is the first unit of its kind ever built and it is powered by a Model AEH 4-cycle, single cylinder air-cooled engine . . . chosen by the designer and builders because of its outstanding dependability and ease of regulation.

Wisconsin Heavy-Duty Air-Cooled Engines are selected for the same reasons for powering many other types of equipment in oil field service.

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.

100% Approval for JUSTRITE

Model No. 44-S

The men who use Justrite Safety lights . . . the men who buy them . . . and the men who inspect for safety . . . *all* give Justrite Safety Lanterns and Flashlights their unqualified approval. They're well-constructed, sturdy, dependable—the best lights for the lowest cost!

All-Purpose Safety Lantern

Justrite Model No. 44-S (left) specially designed for heavy duty. Twin bulbs, famous Justrite "kickout" sockets. Movable guard base permits focussing from many angles. Fixed guard protects globe. Guards are sparkproofed to meet safety requirements. Uses standard 6-volt battery.

Handy-Safety Flashlight

Justrite Model No. 17-S (at right) has sturdy plastic case that seals in all the famous Justrite features. Throws 1500 candlepower beam from 3 standard cells. Fits in palm of hand, on belt clip, or stands on flat surface. Signal flasher switch, water resistant.

Model No. 17-S

Both these lights listed for Safety by Underwriters' Laboratories, Inc., by U. S. Bureau of Mines and U. S. Bureau of Marine Inspection.

For complete details ask your Distributor or send for catalogue.

JUSTRITE MANUFACTURING COMPANY
2063 N. Southport Ave., Dept. G-2, Chicago 14, Illinois

sure and have a steady non-pulsating delivery.

The pumps are built in various sizes and capacities, the smallest having a range of 5 to 300 gal. per hr., and the largest standard pump 1880 to 3765 gal. per hr. Other sizes can be built to order.

(13) *Bowen overshot*

Where a small, compact, single bowl overshot is desired for catching one specific size of pipe, tool joint, coupling, or drill collar, the new Series 150 Bowen Releasing Overshot manufactured by S. R. Bowen Company, Huntington Beach, California, is a particularly valuable tool. The small outside diameter of this tool enables it to be used under tight hole conditions that would normally eliminate an outside releasing fishing tool, yet it is so designed that strength of the bowl is not sacrificed for sake of small diameter, according to the manufacturer.

Construction of the Series 150 follows standard Bowen design, including use of the helical grapple that takes a full-length, full-circumferential grip around the pipe, a grip that cinches tighter as upward pull increases, yet releases easily whenever required. A means for packing off around the fish is provided so that circulation can be established through it.

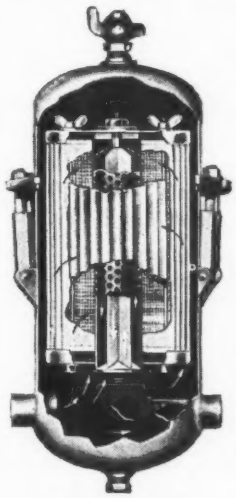
An important feature of the Bowen overshot is that it both sets and releases on right-hand rotation, thus avoiding the dangers of turning the string in an unscrewing direction. Right-hand rotation of the string expands the grapples as the tool is simultaneously lowered over the fish, and simply allowing rotation to stop causes the grapple to take hold around the fish. Thereafter when upward pull is exerted the hold is secure, for the Bowen overshot takes hold as soon as it is over the fish. Release is easily effected by simply bumping down to break the hold and then turning the run-in string to the right to again expand the grapple, and at the same time slowly raising the string until the overshot is clear of the fish.

The Series 150 Bowen Overshot is available in a complete range of sizes in both right and left-hand assemblies, and with undersize grapples and rubbers to catch and pack off tool joints or drill collars.

Poland has imported 38,000 tons of petroleum products and 9000 tons of gasoline from Russia since July, according to the Polish press agency. They reported the price was convenient to Poland when compared with U. S. price quotations.

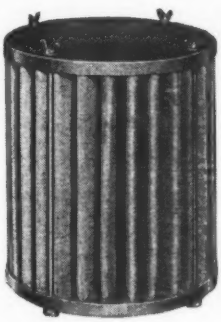
(14) *Liquid filter*

The recently announced Staynew Model ELS filter, manufactured by Dollinger Corporation, Rochester, New York, features an entirely new and, according to the maker, far superior design of filter insert. The insert assembly consists of inner and outer radial finned forms of wire cloth. The outer form, on which the filtering medium is crimped, slips over the inner form. Top and bottom plates and seal gaskets are then applied and the whole assembly held in place by through bolts.



Sectional view.

The new type insert, known as the Slip-On, permits the use of almost any type of filtering medium obtainable in sheet form that can be crimped. It also permits quick change or replacement of filtering medium in the field. Spare insert outer forms are relatively inexpensive and may be stocked in a variety of media ready for instant change or replacement. Thus the Staynew Model ELS Filter is a most versatile liquid filter, with a broad range of applications throughout industry.



Left—Insert assembly removed from pressure housing. Below — Slipping outer medium covered form over inner form.

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(15) *Fuel oil pump*

A new special rotary pumping unit for handling bunker "C" fuel oil and liquids of similar characteristics has been put into production by the Blackmer Pump Company, Grand Rapids, Michigan, according to J. B. Trotman, general sales manager of the company.

The pump is bronze-fitted and operates on the "bucket design" (swinging vane) principle. Due to this construction, the pump is self-adjusting for wear, so that there is no loss of capacity during the life of the "buckets." When worn to the critical point the buckets may be replaced by simply removing the head of the pump, pulling out the worn buckets, and inserting new ones. No adjustments

ELECTRONIC AC VOLTMETER

with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!

ACCESSORIES
MODEL 220 DECADE AMPLIFIER
MODEL 402 MULTIPLIER

Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multirange instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U. S. A.

or "wearing in" are necessary. This replacement restores the pump to normal capacity.

The power unit is a gearhead motor of 50 hp. with a speed of 150 r.p.m. at the driveshaft connected to the pump by a flexible coupling. The pump has a capacity of 500 gal. per min. and operates at a pressure of 125 lb. per sq. in.

(16) *Protecting tubes*

Improved cast-iron thermocouple protecting tubes that it is said will meet advanced requirements of the chemical, metallurgical, and die casting industries have been introduced by the Brown Instrument Company, Philadelphia industrial instrument division of Minneapolis-Honeywell Regulator Company.

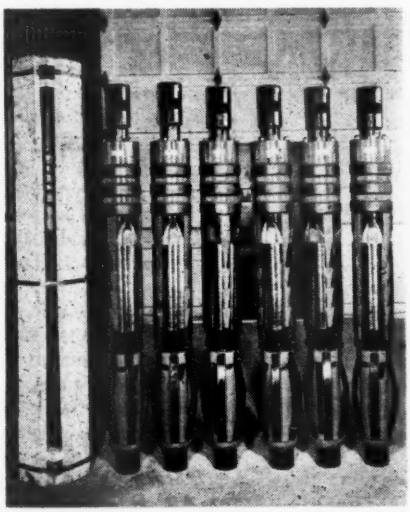
Successful development of the new protecting tubes by Brown engineers resulted from several months of investigation and research to improve the service life of tubes and reduce production costs.

The new tubes have a uniform wall thickness to within plus or minus 1/32 in. and have improved surface finishes, it is said. They are cast with both ends open, permitting positive support for the core at each end. One end is closed with a cast-iron plug, welded in place with a cast-iron filler rod, the opposite end being threaded for a 1-in. standard pipe.

The new tubes, available at lower prices than previous types, have an inside diameter of 13/16 in.; outside diameter of 1⅜ in.; wall thickness of 9/32 in.; a minimum top thickness of 9/32 in., and weighs 4.5 lb.

(17) *Packers*

This is a camera scene of a shipment of large, heavy-duty packers that has been packed by Equipment Engineers, Inc., Dallas, Texas, for the Russian government. The shipment included 18 packers, all of the same design, and included sizes from 8⅝ in. by 3 in. to 8⅝ in. by 5⅓ in. The materials and parts that went to make up the heavy-duty packers were made entirely in the Dallas district —everything from synthetic rubber



packing rings to the steel casting box. Even the packers themselves were designed and built by Dallas engineers and mechanics.

(18) *Remote valve control*

A remote valve control assembly has been developed that provides an increased margin of pipe line safety by facilitating immediate control of valves in hard-to-get-at places. From one easily accessible control board, valves can be opened and closed with a minimum of delay thereby offering a greater degree of control over valves.

These assemblies easily operate and control valves placed below floor level, close to the ceiling or walls and partitions, inside tanks or processing vessels, or in the midst of complicated installations of piping and equipment. The assembly consists of a flexible cable, for transmitting torque to the handle of the valve to be operated, or a rod or pipe connected by universal joints; a remote valve control box, the cover of which can be engraved to identify the type of valve it operates; sleeve bushings, terminal brackets, cable clips, and a rod coupling for the valve wheel.

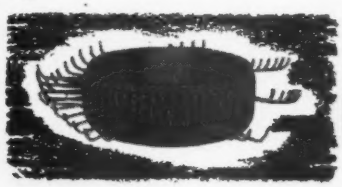
The valve control boxes are made in cast-bronze, steel, semi-steel or iron of various dimensions, and can be attached to masonry construction, metal or wood partitions. The equipment is manufactured by the J. A. Zurn Manufacturing Company, Erie, Pennsylvania.

3 Questions
3 Answers
on Cementing Oil Wells

Q. What is the purpose of cementing an oil string?
A. To prevent migration of gas or water into profitable producing oil sands.

Q. What are the principal causes of cementing failures?
A. (1) Mud cake on the wall of the hole, which prevents the cement from bonding with the formation, allowing water or gas to escape and channel its way to the oil sand. (2) Casing not centered in the hole; this prevents the cement from making a continuous solid sheath around the casing, with the same result as above.

Q. What is the best way to get a good cement job?
A. Use enough B & W Wall Cleaning Guides, properly spaced on the casing, to clean and protect all the producing section, and move the casing while cementing. This simple procedure does three things: centers the casing in the hole, spreads and distributes the cement slurry, and as the casing moves up and down, the spring-steel fingers of the Guides rake the mud cake from the wall of the hole, insuring a clean cement bond with the formation. A simple, inexpensive procedure and the best insurance of a perfect cement job.



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New Efficiency-Balanced

RIGID

PIPE CUTTER

gives you faster, easier, cleaner pipe cutting

Very thin blade cutter wheel speeds cutting
RIGID
No. 2 HEAVY DUTY
1/8 TO 2"
If this Housing ever Breaks or Distorts we will replace it Free

RIGID Tubing Cutter with rolls—quick cutting of any tubing or thin-wall conduit.

● You like the feel of it—the neatly balanced design of the rugged new style malleable frame tells your practiced hand that it's going to cut pipe with easy speed. And it does—the thin tool-steel blade wheel always cuts true, fast, almost without burr. Every cutter is carefully factory tested before shipment. Five sizes to 6," two 4-wheel cutters to 4." For pipe cutting with least effort—ask your Supply House for the new, efficient RIGID Cutter.

RIGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY · ELYRIA, OHIO, U. S. A.

TRADE LITERATURE

Publications listed are sent free upon request.

(19) *Emsco bulletins released*

Emsco Derrick and Equipment Company, Los Angeles, California, has issued three bulletins that describe and show in illustration drilling equipment manufactured by the company. Bulletin No. 169-E concerns Emsco swivels, No. 170-E Emsco pin type drillstem bushings, and No. 171-E Emsco slush pumps.

(20) *Leather packings*

Alexander Brothers, Philadelphia, Pennsylvania, have issued two folders. One folder presents a table of standards governing the correct proportions and dimensions of leather packings for almost every purpose. The second folder is in four colors and pictures an assortment of various Alexander leather packings. and describes the 4 most generally used shapes.

(21) *Leather belting*

Data on notched leather Vee-shaped belting manufactured by the S. R. Sikes Company of Chicago, Illinois, and Minneapolis, Minnesota, are contained in a bulletin recently published. Distributor for the belting is the Weiss Supply Company. Tulsa, Oklahoma.

(22) *Cathodic protection*

Federal Telephone and Radio Corporation, Newark, New Jersey, has issued a reprint of an article entitled "Cathodic Protection and Applications of Selenium Rectifiers," by W. F. Bonner of the company. The article originally was published in *Electrical Communication*, technical journal of the International Telephone and Telegraph Corporation.

(23) *Needle bearing catalog*

The Torrington Company, Bantam Bearing Division, South Bend, Indiana, has issued its needle bearing catalog. The publication contains complete specifications for standard Torrington needle bearings and presents numerous features of this type of equipment. The catalog is replete with illustrations and engineering and application data.

(24) *Worthington bulletins*

Multi-stage centrifugal pipe line pumps are described in bulletin W-318-B1C, released by Worthington Pump and Machinery Corporation, Harrison, New Jersey. Another bulletin by the same company, H-450-B33, discusses a few of the many services to which Worthington vertical turbine pumps may be applied.

(25) *Reference chart*

A new and unusual reference chart on high and low alloy welding electrodes has been announced by Arcos Corporation, Philadelphia, Pennsylvania. The data include tables on corrosion resistance, on heat resistance, and on weld metal surfacing, as well as the chemistry of the weld metal. Welding current and voltage tables give information of value to the operator. The chart is 20 in. by 30 in. for wall mounting.

(26) *Steam control*

O. C. Keckley Company, Chicago, has issued a 1945 catalog consisting of 40 pages, illustrating and describing steam and liquid control equipment that includes precision pressure regulating valves, pump governors, temperature regulators, relief valves, float valves, self-cleaning strainers, water gages, gage cocks, illuminators, and steam traps.

(27) *Arc welder*

New and improved Wilson "Bumblebee" alternating current transformer arc-welding machines are described fully in a 16-page illustrated booklet published by Air Reduction, New York City. Among the machines described are the 300 and 500 amp. standard and all-weather models, and the new 200 amp. "Bumblebee," which has been designed to meet the demands for a small arc welder comparable in performance with the big

"Bumblebees." Engineering data and complete specifications are supplied. Precise labeled drawings and numerous photographs supplement the text.

(28) *Refining processes*

A new 60-page brochure, "Petroleum Refining Processes," R-9, containing the latest data on catalytic cracking, Polyform, lubricating oil, solvent refining and dewaxing, and petroleum chemical processes, has been issued by The Lummus Company, New York, New York.

Featuring 22 full-page flow charts of latest refinery processes, the book is a valuable aid to large and small refiners who must convert war facilities to peacetime manufacture. It is likewise of help to refiners who must build new equipment for the production of high octane motor gasolines.

Illustrated with numerous photographs of various types of process plants designed and built by Lummus, the brochure also gives specification and installation data on Lummus oil heaters and Lummus heat exchange equipment.

(29) *Renewable chart*

A new valve renewable parts chart has been published by the Reading-Pratt and Cady Division of the American Chain and Cable Company, Inc. An ideal source of information for new men in industry, this chart will also help the plant veterans who have asked for just such information. Purchase departments too can put this informative data to work. The chart gives pictures and data on brass and iron valves with vital parts that can be renewed. The chart also tells how to renew and replace worn out parts, and offers in one-two-three order the facts that should be remembered when ordering new parts.

(30) *Deaeration*

A restatement of the science of deaeration and its effectiveness in controlling corrosion is the major part of a 20-page booklet issued by the Elliott Company, Jeannette, Pennsylvania, manufacturers of power plant equipment.

Fully illustrated with charts and photographs, the booklet describes corrosion in general and the part that deaeration plays in checking it. Included in the text is a table showing the derivation of the pH factor and a graph indicating the effect of pH on the rate of corrosion. Additional graphs cover the solubility of oxygen and carbon dioxide in water at various temperatures and the solubility of the oxygen component of air in distilled water at various temperatures and pressures.

(31) *Piping layouts*

Conclusions of prefabricated power piping engineers regarding the design of piping layouts for flexibility have been published in a booklet entitled "Blaw-Knox Functional Spring Hangers and Vibration Eliminators."

The flexibility analysis of a pipe layout—subject to thermal elongation—determines pipe line movements caused by expansion, as well as the anchoring forces, with the resulting stress. A scientifically designed system, including functional spring hangers and vibration eliminators, permits the installation of most economically shaped structures that allow free flexure of entire piping systems in all planes.

(32) *Modern processing*

The economic advantages to the petroleum refining industry of the new and improved processes resulting from recent developments become strikingly evident when put to the test of analysis. A series of 5 economic studies just published by The M. W. Kellogg Company, petroleum engineers, of Jersey City, New Jersey, and New York, New York, shows that the new and improved methods as applied on an individual basis to meet individual needs can reduce overall manufacturing costs per gallon of gasoline, at the same time providing a yield of improved quality to meet peacetime civilian demand. The proposed new operations cited in the five studies put overall manufacturing cost per gallon of gasoline at 5.78 cents, 4.39 cents, 3.66 cents, 4.70 cents and 4.08 cents respectively.

The complete results of these five studies have been made available to the industry in a new booklet, "A Study of Costs—The Economics of Post-war Motor Gasoline Refining."

"The seat assembly is the heart of the valve. I'd design it for dependability!"
Right! That's why LUDLOW STEEL GLOBE VALVES have:
1. A variety of disc and seat ring materials for positive seating under any service.
2. Increased safety-factor through a larger stem-diameter in unsupported section.
3. A hardened steel disc, to take thrust of stem and prevent seizing.
4. A disc readily secured to stem, to simplify regrinding.
More than seventy years of successful designing and manufacture are reflected in the sturdy, positive seating assembly of the Ludlow Cast Steel Globe Valve. As in all Ludlow Valves, the many advantages of construction and design take practical form in long-lasting, ever-dependable service. . . . Write today for complete catalogs.
G-5
1
2
3
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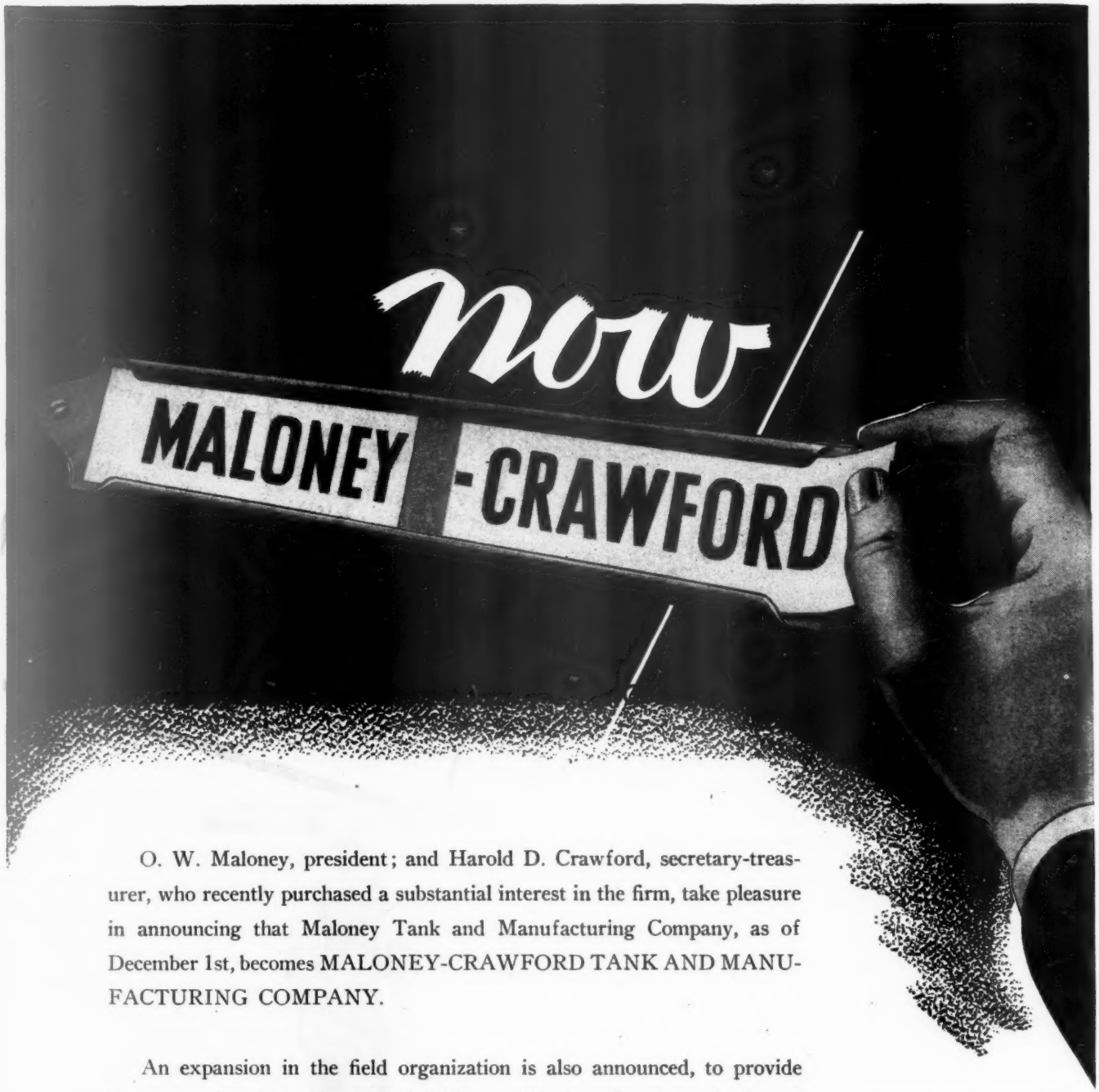
THE LUDLOW VALVE
SINCE 1866
MFG·CO·INC·TROY·N·Y·
Mid-Continent Supply Company, Fort Worth, Texas



O. W. Maloney, president; and Harold D. Crawford, secretary-treasurer, who recently purchased a substantial interest in the firm, take pleasure in announcing that Maloney Tank and Manufacturing Company, as of December 1st, becomes MALONEY-CRAWFORD TANK AND MANUFACTURING COMPANY.

An expansion in the field organization is also announced, to provide the utmost in sales and service facilities on bolted steel tanks, welded steel tanks, oil and gas separators, heaters and treaters.

STOCKS AND SERVICES AVAILABLE AT FOLLOWING PRINCIPAL OIL CENTERS:

Artesia, New Mexico; Odessa, Pampa, Seagraves, Houston and Corpus Christi, Texas; New Orleans and Lafayette, Louisiana; Natchez, Jackson and Laurel, Mississippi; Craig, Colorado; Casper, Wyoming; Cutbank, Montana.

MALONEY-CRAWFORD TANK AND MFG. COMPANY

38 North Peoria **Tulsa, Oklahoma**

MALONEY CRAWFORD

(Successor to Maloney Tank Manufacturing Company)

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 102

A VALUABLE and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue, and 98-100, inclusive, in the October, 1945, issue.

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Volume correction factors for C_3 hydrocarbon mixtures	(sheet 1)	P 213.21	241	Dec.
Volume correction factors for C_4 hydrocarbon mixtures	(sheet 2)	P 213.21	247	Dec.
Pressure drop calculation charts	(sheet 8)	P 511.140.1	255	Nov.
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Specific gravity correction factors for orifice meters	(sheet 1)	P 680.2	261	Nov.
Specific gravity correction factors for orifice meters	(sheet 2)	P 680.2	265	Nov.
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Vapor pressure blending curves for commercial butane	(sheet 6)	P 778.3	259	Nov.
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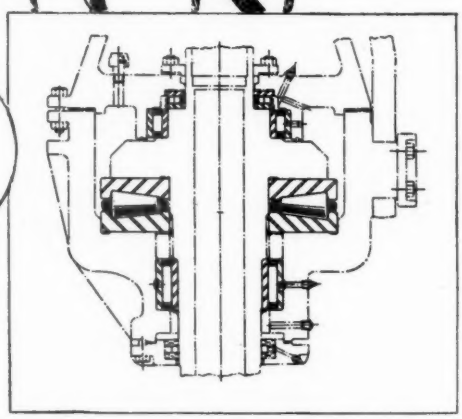
MEETING THE TEST OF HIGHER SWIVEL SPEEDS

As oil well drilling goes ever deeper and operations are speeded up, the load on oil field equipment becomes increasingly severe. This makes the use of Torrington Bearings in swivels and other heavy-duty equipment more advisable today than ever before. Torrington Bearings are specifically designed to assure smooth, efficient operation of moving parts under maximum loads. Long service life and high resistance to wear are characteristic of all Torrington Bearings, large or small.

Many engineers are thoroughly familiar with the advantages of specifying Torrington Bearings for a wide range of oil field equipment . . . and often consult Torrington's Bantam Bearings Division for assistance in the solution of their bearing problems. You can profit by our wide experience in the design and construction of custom-built bearings for routine or unusual applications.

THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA



This Torrington conical roller thrust bearing assures smooth, anti-friction operation of the swivel and has a thrust load capacity of well over 300 tons at more than 300 RPM. Weight of swivel is carried on small double-row thrust bearing at top, and two single-row roller bearings handle the radial load.

TORRINGTON BEARINGS

STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

SPECIFIC GRAVITY[1] CORRESPONDING TO API GRAVITY

Whole degrees, API	plus decimal parts of a degree									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	1.0760	1.0752	1.0744	1.0736	1.0728	1.0720	1.0712	1.0703	1.0695	1.0687
1	1.0679	1.0671	1.0663	1.0655	1.0647	1.0639	1.0631	1.0623	1.0615	1.0607
2	1.0599	1.0591	1.0583	1.0575	1.0568	1.0560	1.0552	1.0544	1.0536	1.0528
3	1.0520	1.0513	1.0505	1.0497	1.0489	1.0481	1.0474	1.0466	1.0458	1.0451
4	1.0443	1.0435	1.0427	1.0420	1.0412	1.0404	1.0397	1.0389	1.0382	1.0374
5	1.0366	1.0359	1.0351	1.0344	1.0336	1.0328	1.0321	1.0313	1.0306	1.0298
6	1.0291	1.0283	1.0276	1.0269	1.0261	1.0254	1.0246	1.0239	1.0231	1.0224
7	1.0213	1.0209	1.0202	1.0195	1.0187	1.0180	1.0173	1.0165	1.0158	1.0151
8	1.0143	1.0136	1.0129	1.0122	1.0114	1.0107	1.0100	1.0093	1.0086	1.0078
9	1.0071	1.0064	1.0057	1.0050	1.0043	1.0035	1.0028	1.0021	1.0014	1.0007
10	1.0000	0.9993	0.9986	0.9979	0.9972	0.9965	0.9958	0.9951	0.9944	0.9937
11	0.9930	0.9923	0.9916	0.9909	0.9902	0.9895	0.9888	0.9881	0.9874	0.9868
12	0.9861	0.9854	0.9847	0.9840	0.9833	0.9826	0.9820	0.9813	0.9806	0.9799
13	0.9792	0.9786	0.9779	0.9772	0.9765	0.9759	0.9752	0.9745	0.9738	0.9732
14	0.9725	0.9718	0.9712	0.9705	0.9698	0.9692	0.9685	0.9679	0.9672	0.9665
15	0.9659	0.9652	0.9646	0.9639	0.9632	0.9626	0.9619	0.9613	0.9606	0.9600
16	0.9593	0.9587	0.9580	0.9574	0.9567	0.9561	0.9554	0.9548	0.9541	0.9535
17	0.9529	0.9522	0.9516	0.9509	0.9503	0.9497	0.9490	0.9484	0.9478	0.9471
18	0.9465	0.9459	0.9452	0.9446	0.9440	0.9433	0.9427	0.9421	0.9415	0.9408
19	0.9402	0.9396	0.9390	0.9383	0.9377	0.9371	0.9365	0.9358	0.9352	0.9346
20	0.9340	0.9334	0.9328	0.9321	0.9315	0.9309	0.9303	0.9297	0.9291	0.9285
21	0.9279	0.9273	0.9267	0.9260	0.9254	0.9248	0.9242	0.9236	0.9230	0.9224
22	0.9218	0.9212	0.9206	0.9220	0.9194	0.9188	0.9182	0.9176	0.9170	0.9165
23	0.9159	0.9153	0.9147	0.9141	0.9135	0.9129	0.9123	0.9117	0.9111	0.9106
24	0.9100	0.9094	0.9088	0.9082	0.9076	0.9071	0.9065	0.9059	0.9053	0.9047
25	0.9042	0.9036	0.9030	0.9024	0.9018	0.9013	0.9007	0.9001	0.8996	0.8990
26	0.8984	0.8978	0.8973	0.8967	0.8961	0.8956	0.8950	0.8944	0.8939	0.8933
27	0.8927	0.8922	0.8916	0.8911	0.8905	0.8899	0.8894	0.8888	0.8883	0.8877
28	0.8871	0.8866	0.8860	0.8855	0.8849	0.8844	0.8838	0.8833	0.8827	0.8822
29	0.8816	0.8811	0.8805	0.8800	0.8794	0.8789	0.8783	0.8778	0.8772	0.8767
30	0.8762	0.8756	0.8751	0.8745	0.8740	0.8735	0.8729	0.8724	0.8718	0.8713
31	0.8708	0.8702	0.8697	0.8692	0.9686	0.8681	0.8676	0.8670	0.8665	0.8660
32	0.8654	0.8649	0.8644	0.8639	0.8633	0.8628	0.8623	0.8618	0.8612	0.8607
33	0.8602	0.8597	0.8591	0.8586	0.8581	0.8576	0.8571	0.8565	0.8560	0.8555
34	0.8550	0.8545	0.8540	0.8534	0.8529	0.8524	0.8519	0.8514	0.8509	0.8504
35	0.8498	0.8493	0.8488	0.8433	0.8478	0.8473	0.8468	0.8463	0.8458	0.8453
36	0.8448	0.8443	0.8438	0.8433	0.8428	0.8423	0.8418	0.8413	0.8408	0.8403
37	0.8398	0.8393	0.8388	0.8383	0.8378	0.8373	0.8368	0.8363	0.8358	0.8353
38	0.8348	0.8343	0.8338	0.8333	0.8328	0.8324	0.8319	0.8314	0.8309	0.8304
39	0.8299	0.8294	0.8289	0.8285	0.8280	0.8275	0.8270	0.8265	0.8260	0.8256
40	0.8251	0.8246	0.8241	0.8236	0.8232	0.8227	0.8222	0.8217	0.8212	0.8208
41	0.8203	0.8198	0.8193	0.8189	0.8184	0.8179	0.8174	0.8170	0.8165	0.8160
42	0.8156	0.8151	0.8146	0.8142	0.8137	0.8132	0.8128	0.8123	0.8118	0.8114
43	0.8109	0.8104	0.8100	0.8095	0.8090	0.8086	0.8081	0.8076	0.8072	0.8067
44	0.8063	0.8058	0.8054	0.8049	0.8044	0.8040	0.8035	0.8031	0.8026	0.8022
45	0.8017	0.8012	0.8008	0.8003	0.7999	0.7994	0.7990	0.7985	0.7981	0.7976
46	0.7972	0.7967	0.7963	0.7958	0.7954	0.7949	0.7945	0.7941	0.7936	0.7932
47	0.7927	0.7923	0.7918	0.7914	0.7909	0.7905	0.7901	0.7986	0.7982	0.7887
48	0.7883	0.7879	0.7874	0.7870	0.7865	0.7861	0.7857	0.7852	0.7848	0.7844
49	0.7839	0.7835	0.7831	0.7826	0.7822	0.7818	0.7813	0.7809	0.7805	0.7800

*NOTE: This table replaces Sheet 1, P213.1, published in Installment No. 24 in June, 1939.

[1]The specific gravity corresponding to an API gravity of 32.7 deg., for example, will be found on line "32" in column "0.7" = 0.8618.

The above factors are based on the formula:

$$\text{Specific gravity } 60^\circ \text{ F.}/60^\circ \text{ F. (vacuo/vacuo)} = \frac{141.5}{\text{deg. API} + 131.5}$$

Example of use of the table by interpolation:

Given: The gravity of an oil is reported to be 32.75 deg. API at 60° F.

Required: The equivalent 60° F./60° F. specific gravity at 60° F.

Solution: The table shows: 32.7 deg. API = specific gravity 0.8618
32.8 deg. API = specific gravity 0.8612
Then, a rise of 0.1 deg. API = a specific gravity reduction of 0.0006
and, by proportion, a rise of 0.05 deg. API = a specific gravity reduction of 0.0003
Therefore, 32.75 deg. API = 0.8618 — 0.0003, or 0.8615 specific gravity.

More Dry Oil Per Pint of Chemical

VISCO

The MODERN EMULSION BREAKER is *always*

FAST– EFFICIENT– ECONOMICAL

• • •

TO INCREASE DAILY THROUGHPUT WITH HIGHER OPERATING TEMPERATURES USE VISCO'S DESALTING PROCESS

Ask about VISCOSOL THE SUCCESSFUL Paraffin inhibitor

Oil is a national necessity. We owe it to ourselves to maintain its production at maximum efficiency. We pledge to do our part.

VISCO

VISCO PRODUCTS COMPANY, INC., Houston, Texas

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VAPOR PRESSURE BLENDING CURVES FOR COMMERCIAL BUTANE

NOTE: Since the vapor pressure of the depropanizer reflux will rarely be exactly 175, 200, 225, 250, 275, or 300 lb. per sq. in. as assumed in Figs. 2 to 7 (sheets 2 to 7), is necessary to interpolate between different reflux vapor pressures. Fig. 8 was constructed to determine the limits within which linear interpolation is sufficiently accurate, and the amount and direction of the error introduced by linear interpolation. Fig. 8 shows that linear interpolation, using Figs. 2 to 7, is least accurate for low vapor pressures of depropanizer reflux (from 175 to 200 lb. per sq. in.), and for high vapor pressures of final blend (from 100 to 120 lb. per sq. in.)

EXAMPLE:

Given: Vapor pressure of 10,000 gal. of pure N-butane = 37.3 lb. per sq. in.

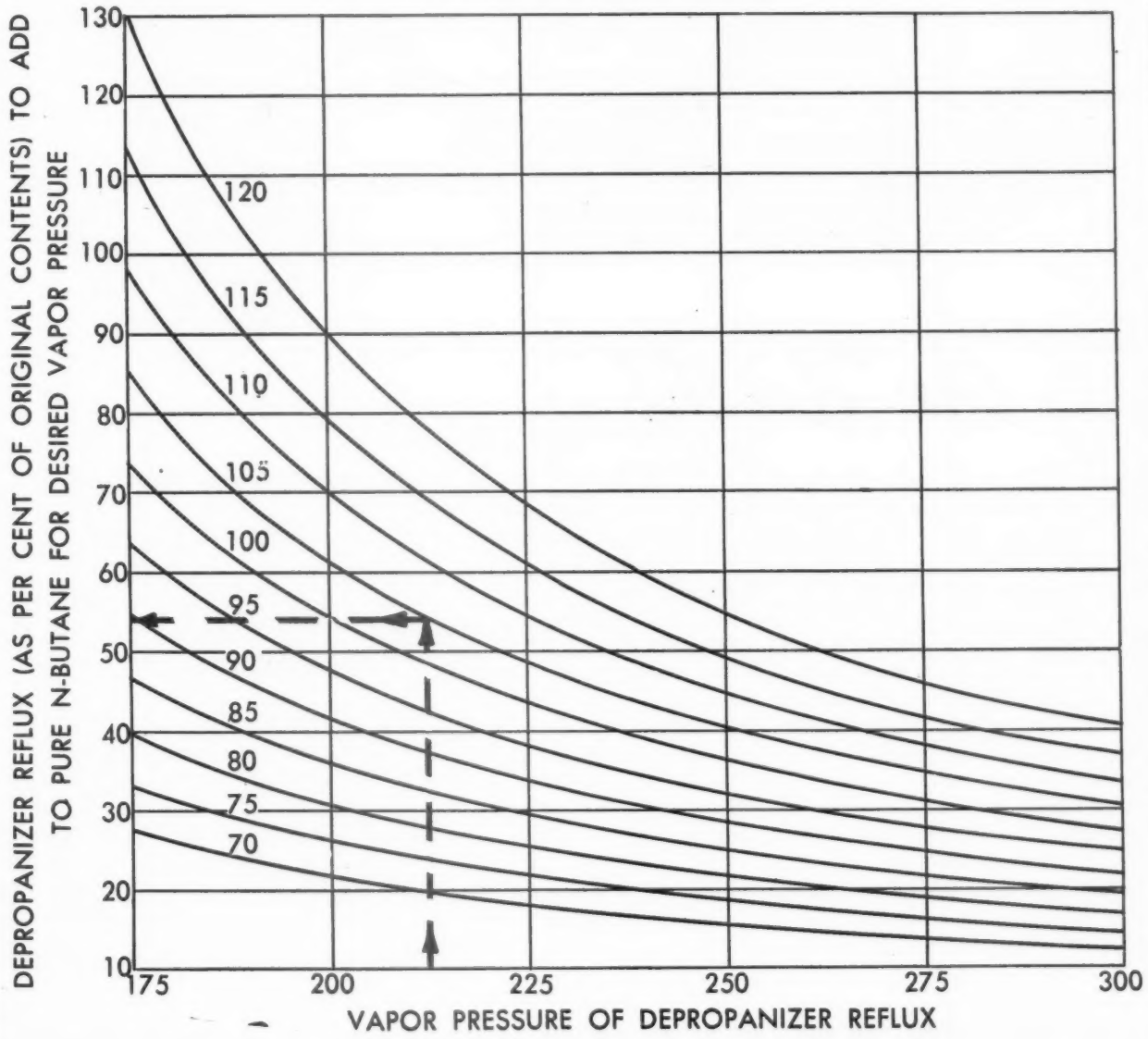
Vapor pressure of depropanizer reflux = 212.5 lb. per sq. in.

Required: A final blend of 105 lb. per sq. in.

Solution: Enter on the 212.5 lb. line on the horizontal scale (halfway between 200 and 225). Proceed upward to the 105 lb. per sq. in. final blend curve as indicated by dashed line and arrows. Then, proceed to vertical scale. The reading is 54 per cent.

Then, .54 by 10,000 gal. = 5400 gal. of 212.5 lb. per sq. in. depropanizer reflux to be added to obtain a final blend of 105 lb. per sq. in.

FIG. 8. Depropanizer reflux as per cent of original contents to add to pure N-butane for desired vapor pressure.



This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY
323 WILSON, SO. NORWALK, CONN.

SPECIFIC GRAVITY[1] CORRESPONDING TO API GRAVITY

Whole degrees, API	plus decimal parts of a degree									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
50	0.7796	0.7792	0.7788	0.7783	0.7779	0.7775	0.7770	0.7766	0.7762	0.7758
51	0.7753	0.7749	0.7745	0.7741	0.7736	0.7732	0.7728	0.7724	0.7720	0.7715
52	0.7751	0.7707	0.7703	0.7699	0.7694	0.7690	0.7686	0.7682	0.7678	0.7674
53	0.7669	0.7665	0.7661	0.7657	0.7653	0.7649	0.7645	0.7640	0.7636	0.7632
54	0.7628	0.7624	0.7620	0.7616	0.7612	0.7608	0.7603	0.7599	0.7595	0.7591
55	0.7587	0.7583	0.7579	0.7575	0.7571	0.7567	0.7563	0.7559	0.7555	0.7551
56	0.7547	0.7543	0.7539	0.7535	0.7531	0.7527	0.7523	0.7519	0.7515	0.7511
57	0.7507	0.7503	0.7499	0.7495	0.7491	0.7487	0.7483	0.7479	0.7475	0.7471
58	0.7467	0.7463	0.7459	0.7455	0.7451	0.7447	0.7443	0.7440	0.7436	0.7432
59	0.7428	0.7424	0.7420	0.7416	0.7412	0.7408	0.7405	0.7401	0.7397	0.7393
60	0.7389	0.7385	0.7381	0.7377	0.7374	0.7370	0.7366	0.7262	0.7358	0.7354
61	0.7351	0.7347	0.7343	0.7339	0.7335	0.7332	0.7328	0.7324	0.7320	0.7316
62	0.7313	0.7309	0.7305	0.7301	0.7298	0.7294	0.7290	0.7286	0.7283	0.7279
63	0.7275	0.7271	0.7268	0.7264	0.7260	0.7256	0.7253	0.7249	0.7245	0.7242
64	0.7238	0.7234	0.7230	0.7227	0.7223	0.7219	0.7216	0.7212	0.7208	0.7205
65	0.7201	0.7197	0.7194	0.7190	0.7186	0.7183	0.7179	0.7175	0.7172	0.7168
66	0.7165	0.7161	0.7157	0.7154	0.7150	0.7146	0.7143	0.7139	0.7136	0.7132
67	0.7128	0.7125	0.7121	0.7118	0.7114	0.7111	0.7107	0.7103	0.7100	0.7096
68	0.7093	0.7089	0.7086	0.7082	0.7079	0.7075	0.7071	0.7068	0.7064	0.7061
69	0.7057	0.7054	0.7050	0.7047	0.7043	0.7040	0.7036	0.7033	0.7029	0.7026
70	0.7022	0.7019	0.7015	0.7012	0.7008	0.7005	0.7001	0.6998	0.6995	0.6991
71	0.6988	0.6984	0.6981	0.6977	0.6974	0.6970	0.6967	0.6964	0.6960	0.6957
72	0.6953	0.6950	0.6946	0.6943	0.6940	0.6936	0.6933	0.6929	0.6926	0.6923
73	0.6919	0.6916	0.6913	0.6909	0.6906	0.6902	0.6899	0.6896	0.6892	0.6889
74	0.6886	0.6882	0.6879	0.6876	0.6872	0.6869	0.6866	0.6862	0.6859	0.6856
75	0.6852	0.6849	0.6846	0.6842	0.6832	0.6836	0.6832	0.6829	0.6826	0.6823
76	0.6819	0.6816	0.6813	0.6809	0.6806	0.6803	0.6800	0.6796	0.6793	0.6790
77	0.6787	0.6783	0.6780	0.6777	0.6774	0.6770	0.6767	0.6764	0.6761	0.6757
78	0.6754	0.6751	0.6748	0.6745	0.6741	0.6738	0.6735	0.6732	0.6728	0.6725
79	0.6722	0.6719	0.6716	0.6713	0.6709	0.6706	0.6703	0.6700	0.6697	0.6693
80	0.6690	0.6687	0.6684	0.6681	0.6678	0.6675	0.6671	0.6668	0.6665	0.6662
81	0.6659	0.6656	0.6653	0.6649	0.6646	0.6643	0.6640	0.6637	0.6634	0.6631
82	0.6628	0.6625	0.6621	0.6618	0.6615	0.6612	0.6609	0.6606	0.6603	0.6600
83	0.6597	0.6594	0.6591	0.6588	0.6584	0.6581	0.6578	0.6575	0.6572	0.6569
84	0.6566	0.6463	0.6560	0.6557	0.6554	0.6551	0.6548	0.6545	0.6542	0.6439
85	0.6536	0.6533	0.6530	0.6527	0.6524	0.6521	0.6518	0.6515	0.6512	0.6509
86	0.6506	0.6503	0.6500	0.6497	0.6494	0.6491	0.6488	0.6485	0.6482	0.6479
87	0.6476	0.6473	0.6470	0.6467	0.6464	0.6461	0.6458	0.6455	0.6452	0.6449
88	0.6446	0.6444	0.6441	0.6438	0.6435	0.6432	0.6429	0.6426	0.6423	0.6420
89	0.6417	0.6414	0.6411	0.6409	0.6406	0.6403	0.6400	0.6397	0.6394	0.6391
90	0.6388	0.6385	0.6382	0.6380	0.6377	0.6374	0.6371	0.6368	0.6365	0.6362
91	0.6360	0.6357	0.6354	0.6351	0.6348	0.6345	0.6342	0.6340	0.6337	0.6334
92	0.6331	0.6328	0.6325	0.6323	0.6320	0.6317	0.6314	0.6311	0.6309	0.6306
93	0.6303	0.6300	0.6297	0.6294	0.6292	0.6289	0.6286	0.6283	0.6281	0.6278
94	0.6275	0.6272	0.6269	0.6267	0.6264	0.6261	0.6258	0.6256	0.6253	0.6250
95	0.6247	0.6244	0.6242	0.6239	0.6236	0.6233	0.6231	0.6228	0.6225	0.6223
96	0.6220	0.6217	0.6214	0.6212	0.6209	0.6206	0.6203	0.6201	0.6198	0.6195
97	0.6193	0.6190	0.6187	0.6184	0.6182	0.6179	0.6176	0.6174	0.6171	0.6128
98	0.6166	0.6163	0.6160	0.6158	0.6155	0.6152	0.6150	0.6147	0.6144	0.6141
99	0.6139	0.6136	0.6134	0.6131	0.6128	0.6126	0.6123	0.6120	0.6118	0.6115

[1]The specific gravity corresponding to an API gravity of 74.5 deg., for example, will be found on line "74" in column "0.5" = 0.6869.

NOTE: The factors in the above table are based on the formula:

$$\text{Specific gravity } 60^\circ \text{ F.}/60^\circ \text{ F. (vacuo/vacuo)} = \frac{141.5}{\text{deg. API} + 131.5}$$

Example of use of the table by interpolation:

Given: The gravity of an oil is reported to be 74.53 deg. API at 60° F.

Required: The equivalent 60° F./60° F. specific gravity at 60° F.

Solution: The table shows: 74.5 deg. API = specific gravity 0.6869
74.6 deg. API = specific gravity 0.6866
then, a rise of 0.1 deg. API = a specific gravity reduction of 0.0003
and, by proportion, a rise of 0.03 deg. API = a specific gravity reduction of 0.0001
Therefore, 74.53 deg. API = 0.6869 — 0.0001, or 0.6868 specific gravity.

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VOLUME CORRECTION FACTORS FOR C_4 HYDROCARBON MIXTURES

TABLE 1

Approximate values* for coefficient of expansion at 60° F. and other properties for 30 C_3, C_4 and C_5 hydrocarbons.

Hydrocarbon	Coefficient of expansion at 60°F. (°F)-1	Specific gravity at 60°/60°F.	Normal boiling point, °F.	Vapor pressure at 100°F., lb. per sq. in. abs.
Paraffins				
propane	0.00162	0.508	—44	189
n-butane	0.00107	0.584	31	52
2-methylpropane (iso-butane)	0.00118	0.563	11	73
n-pentane	0.00086	0.631	97	16
2-methylbutane (iso-pentane)	0.00088	0.625	82	20
2, 2-dimethylpropane (neopentane)	0.00102	0.596	49	38
Monoolefins				
propene (propylene)	0.00174	0.522	—54	226
1-butene (butylene)	0.00113	0.601	21	62
cis-2-butene (butylene)	0.00104	0.627	39	46
trans-2-butene (butylene)	0.00105	0.610	34	50
iso-butene (butylene)	0.00112	0.600	20	63
1-pentene (amylene)	0.00088	0.647	86	19
cis-2-pentene (amylene)	0.00084	0.661	99	15
trans-2-pentene (amylene)	0.00083	0.654	97	16
3-methyl-1-butene (isoamylene)	0.00093	0.633	68	26
2-methyl-2-butene (trimethylethylene)	0.00082	0.668	101	14
Diolefins				
propadiene (Allene)	0.00140†	0.595†	—30	150
1, 2-butadiene	0.00098	0.658	51	36
1, 3-butadiene	0.00108	0.627	24	59
cis-1, 3-pentadiene (piperlylene)	0.00080	0.696	112	12
trans-1, 3-pentadiene (piperlylene)	0.00081	0.682	108	13
1, 4-pentadiene	0.00088	0.665	79	22
2-methyl-1, 3-butadiene (isoprene)	0.00081	0.686	93	17
Acetylenes				
propyne (methylacetylene)	0.00120†	0.622†	—10	105
2-butyne (dimethylacetylene)	0.00085	0.698	80	21
3-methyl-1-butyne	0.00086	0.670	82	20
Cycloparaffins				
cyclopropane	0.00130†	0.616†	—27	142
cyclopentane	0.00073	0.750	121	10
methylcyclobutane	0.00081	0.698	102	14
ethylcyclopropane	0.00080	0.682	94	16

*Obtained largely from various sources, including International Critical Tables; Physical Constants of Hydrocarbons, Egloff, ACS Monograph; Physical Constants of the Principal Hydrocarbons, Doss, The Texas Company; National Bureau of Standards LC-736, and similar compilations, which may be consulted for references to experimental data.

†Obtained from data over the range —20° to —80° C. given by Grosse and Linn, J. Am. Chem. Soc., 61, 751, 1939, by extrapolating to 60° F. and assuming law of rectilinear diameter.

Examples of use:

Given: A mixture of C_4 hydrocarbons having the approximate composition:

mol per cent	*Hydrocarbon*
10	n-butane
20	iso-butane
40	1-butene
30	1, 3-butadiene

Required: Vapor pressure of mixture at 100° F.

Formula: $P + X_1P_1 + X_2P_2 + X_3P_3 + X_4P_4$.

Substituting: $P = (.1)(52) + (.2)(73) + (.4)(62) + (.3)(59)$.

Solving: $P = 5.2 + 14.6 + 24.8 + 17.7 = 62.3$ lb. per sq. in., abs. at 100° F.

From National Bureau of Standards Letter Circular LC757.

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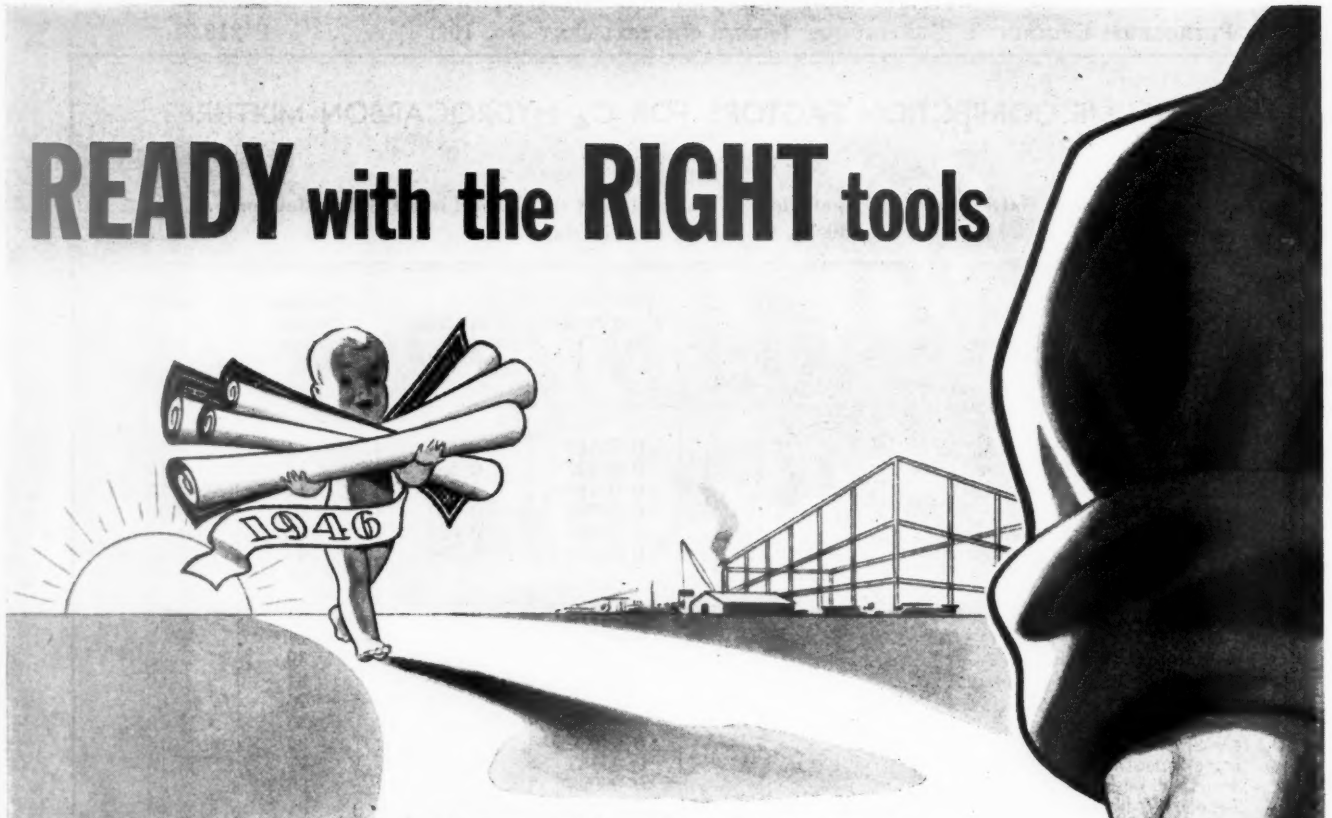

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SPECIFIC GRAVITY[1] CORRESPONDING TO API GRAVITY

Whole degrees, API	plus decimal parts of a degree									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
100	0.6112	0.6110	0.6107	0.6104	0.6102	0.6099	0.6097	0.6094	0.6091	0.6089
101	0.6086	0.6083	0.6081	0.6078	0.6076	0.6073	0.6070	0.6068	0.6065	0.6063
102	0.6060	0.6057	0.6055	0.6052	0.6050	0.6047	0.6044	0.6042	0.6039	0.6037
103	0.6034	0.6032	0.6029	0.6026	0.6024	0.6021	0.6019	0.6016	0.6014	0.6011
104	0.6008	0.6006	0.6003	0.6001	0.5998	0.5996	0.5993	0.5991	0.5988	0.5986
105	0.5983	0.5981	0.5978	0.5976	0.5973	0.5970	0.5968	0.5965	0.5963	0.5960
106	0.5958	0.5955	0.5953	0.5950	0.5948	0.5945	0.5943	0.5940	0.5938	0.5935
107	0.5933	0.5930	0.5928	0.5925	0.5923	0.5921	0.5918	0.5916	0.5913	0.5911
108	0.5908	0.5906	0.5903	0.5901	0.5898	0.5896	0.5893	0.5891	0.5888	0.5886
109	0.5884	0.5881	0.5879	0.5876	0.5874	0.5871	0.5869	0.5866	0.5864	0.5862
110	0.5859	0.5857	0.5854	0.5852	0.5850	0.5847	0.5845	0.5842	0.5840	0.5837
111	0.5835	0.5833	0.5830	0.5828	0.5825	0.5823	0.5821	0.5818	0.5816	0.5813
112	0.5811	0.5809	0.5806	0.5804	0.5802	0.5799	0.5797	0.5794	0.5792	0.5790
113	0.5787	0.5785	0.5783	0.5780	0.5778	0.5776	0.5773	0.5771	0.5768	0.5766
114	0.5764	0.5761	0.5759	0.5757	0.5754	0.5752	0.5750	0.5747	0.5745	0.5743
115	0.5740	0.5738	0.5736	0.5733	0.5731	0.5729	0.5726	0.5724	0.5722	0.5719
116	0.5717	0.5715	0.5713	0.5710	0.5708	0.5706	0.5703	0.5701	0.5699	0.5696
117	0.5694	0.5692	0.5690	0.5687	0.5685	0.5683	0.5680	0.5678	0.5676	0.5674
118	0.5671	0.5669	0.5667	0.5665	0.5662	0.5660	0.5658	0.5655	0.5653	0.5651
119	0.5649	0.5646	0.5644	0.5642	0.5640	0.5637	0.5635	0.5633	0.5631	0.5628
120	0.5626	0.5624	0.5622	0.5620	0.5617	0.5615	0.5613	0.5611	0.5608	0.5606
121	0.5604	0.5602	0.5600	0.5597	0.5595	0.5593	0.5591	0.5588	0.5586	0.5584
122	0.5582	0.5580	0.5577	0.5575	0.5573	0.5571	0.5569	0.5566	0.5564	0.5562
123	0.5560	0.5558	0.5556	0.5553	0.5551	0.5549	0.5547	0.5545	0.5542	0.5540
124	0.5538	0.5536	0.5534	0.5532	0.5530	0.5527	0.5525	0.5523	0.5521	0.5519
125	0.5517	0.5514	0.5512	0.5510	0.5508	0.5505	0.5504	0.5502	0.5499	0.5497
126	0.5495	0.5493	0.5491	0.5489	0.5487	0.5484	0.5482	0.5480	0.5478	0.5476
127	0.5474	0.5472	0.5470	0.5468	0.5465	0.5463	0.5461	0.5459	0.5457	0.5455
128	0.5453	0.5451	0.5449	0.5446	0.5444	0.5442	0.5440	0.5438	0.5436	0.5434
129	0.5432	0.5430	0.5428	0.5426	0.5424	0.5421	0.5419	0.5417	0.5415	0.5413
130	0.5411	0.5409	0.5407	0.5405	0.5403	0.5401	0.5399	0.5397	0.5395	0.5393
131	0.5390	0.5388	0.5386	0.5384	0.5382	0.5380	0.5378	0.5376	0.5374	0.5372
132	0.5370	0.5368	0.5366	0.5364	0.5362	0.5360	0.5358	0.5356	0.5354	0.5352
133	0.5350	0.5348	0.5346	0.5344	0.5342	0.5340	0.5338	0.5336	0.5334	0.5332
134	0.5330	0.5328	0.5326	0.5324	0.5322	0.5320	0.5318	0.5316	0.5314	0.5312
135	0.5310	0.5308	0.5306	0.5304	0.5302	0.5300	0.5298	0.5296	0.5294	0.5292
136	0.5290	0.5288	0.5286	0.5284	0.5282	0.5280	0.5278	0.5276	0.5274	0.5272
137	0.5270	0.5268	0.5266	0.5264	0.5262	0.5260	0.5258	0.5256	0.5254	0.5252
138	0.5250	0.5249	0.5247	0.5245	0.5243	0.5241	0.5239	0.5237	0.5235	0.5233
139	0.5231	0.5229	0.5227	0.5225	0.5223	0.5221	0.5219	.05218	0.5216	0.5214
140	0.5212	0.5210	0.5208	0.5206	0.5204	0.5202	0.5200	0.5198	0.5196	0.5195
141	0.5193	0.5191	0.5189	0.5187	0.5185	0.5183	0.5181	0.5179	0.5177	0.5176
142	0.5174	0.5172	0.5170	0.5168	0.5166	0.5164	0.5162	0.5160	0.1559	0.5157
143	0.5155	0.5153	0.5151	0.5149	0.5147	0.5145	0.5144	0.5142	0.5140	0.5138
144	0.5136	0.5134	0.5132	0.5131	0.5129	0.5127	0.5125	0.5123	0.5121	0.5119
145	0.5118	0.5116	0.5114	0.5112	0.5110	0.5108	0.5106	0.5105	0.5103	0.5101
146	0.5099	0.5097	0.5095	0.5094	0.5092	0.5090	0.5088	0.5086	0.5084	0.5083
147	0.5081	0.5079	0.5077	0.5075	0.5074	0.5072	0.5070	0.5068	0.5066	0.5064
148	0.5063	0.5061	0.5059	0.5057	0.5055	0.5054	0.5052	0.5050	0.5048	0.5046
149	0.5045	0.5043	0.5041	0.5039	0.5037	0.5036	0.5034	0.5032	0.5030	0.5028
150	0.5027	0.5025	0.5023	0.5021	0.5019	0.5018	0.5016	0.5014	0.5012	0.5010

[1]The specific gravity corresponding to an API gravity of 130.4 deg., for example, will be found on line "130" in column "0.4" = 0.5403.

NOTE: The factors in the above table are based on the formula:

$$\text{Specific gravity } 60^\circ \text{ F.}/60^\circ \text{ F. (vacuo/vacuo)} = \frac{141.5}{\text{deg. API} + 131.5}$$

Example of use of the table by interpolation:

Given: The gravity of an oil is reported to be 130.45 deg. API at 60° F.

Required: The equivalent 60° F./60° F. specific gravity at 60° F.

Solution: The table shows: 130.4 deg. API = specific gravity 0.5403
130.5 deg. API = specific gravity 0.5401
then, a rise of 0.1 deg. API gravity = a specific gravity reduction of 0.0002
and, by proportion, a rise of 0.05 deg. API gravity = a specific gravity reduction of 0.0001
Therefore, 130.45 deg. API = 0.5403 — 0.0001, or 0.5402 specific gravity.

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NOTE: Since the vapor pressure of the depropanizer reflux will rarely be exactly 175, 200, 225, 250, 275, or 300 lb. per sq. in. as assumed in Figs. 2 to 7 (sheets 2 to 7), it is necessary to interpolate between different reflux vapor pressures. Fig. 9 was constructed to determine the limits within which linear interpolation is sufficiently accurate, and the amount and direction of the error introduced by linear interpolation. Fig. 9 shows that linear interpolation, using Fig. 2 to 7, is least accurate for low vapor pressures of depropanizer reflux (from 175 to 200 lb. per sq. in.) and for high vapor pressures of final blend (from 100 to 120 lb. per sq. in.)

EXAMPLE OF CHART USE:

Given: Vapor pressure of 10,000 gal. butane mixture = 70 lb. per sq. in.

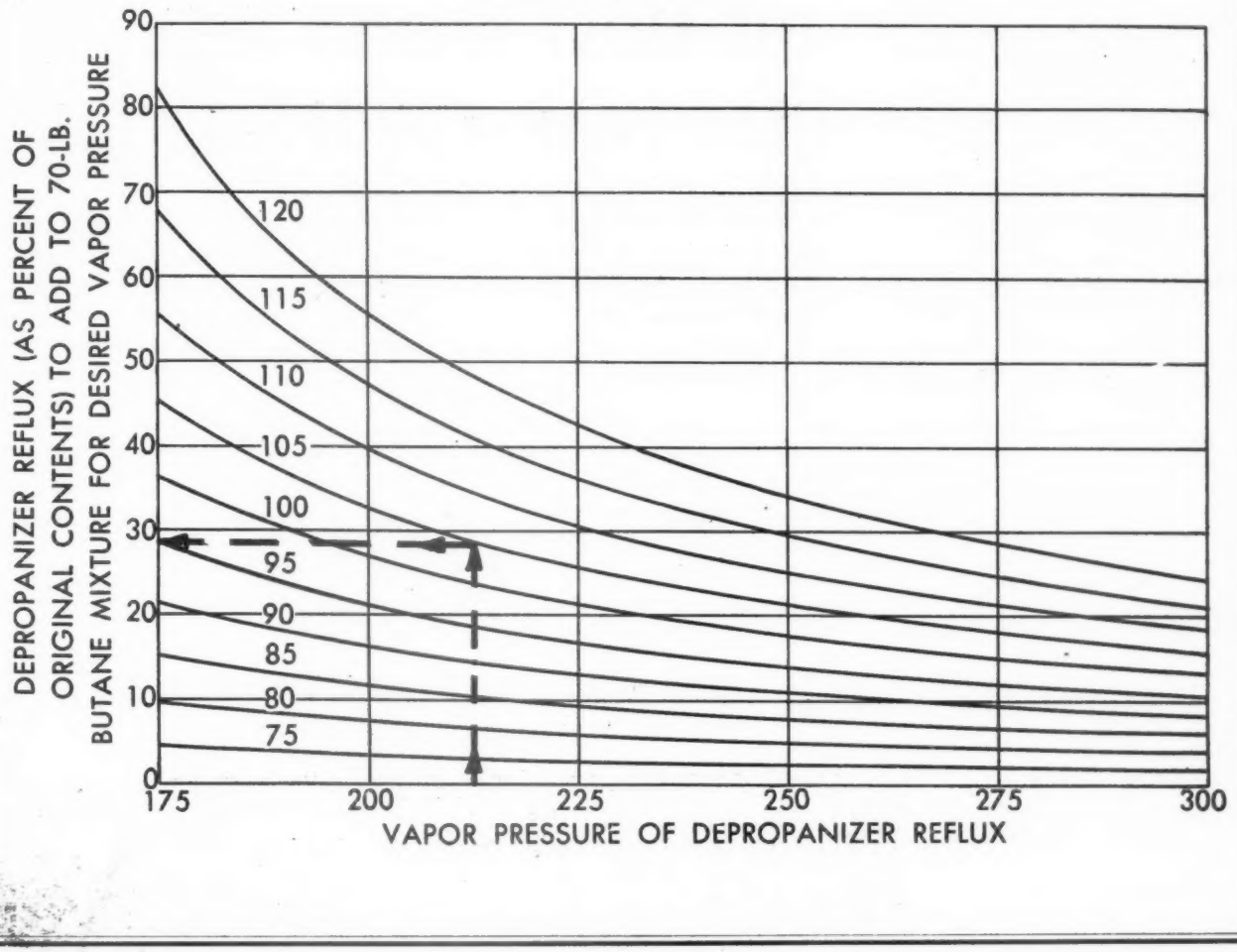
Vapor pressure of depropanizer reflux = 212.5 lb. per sq. in.

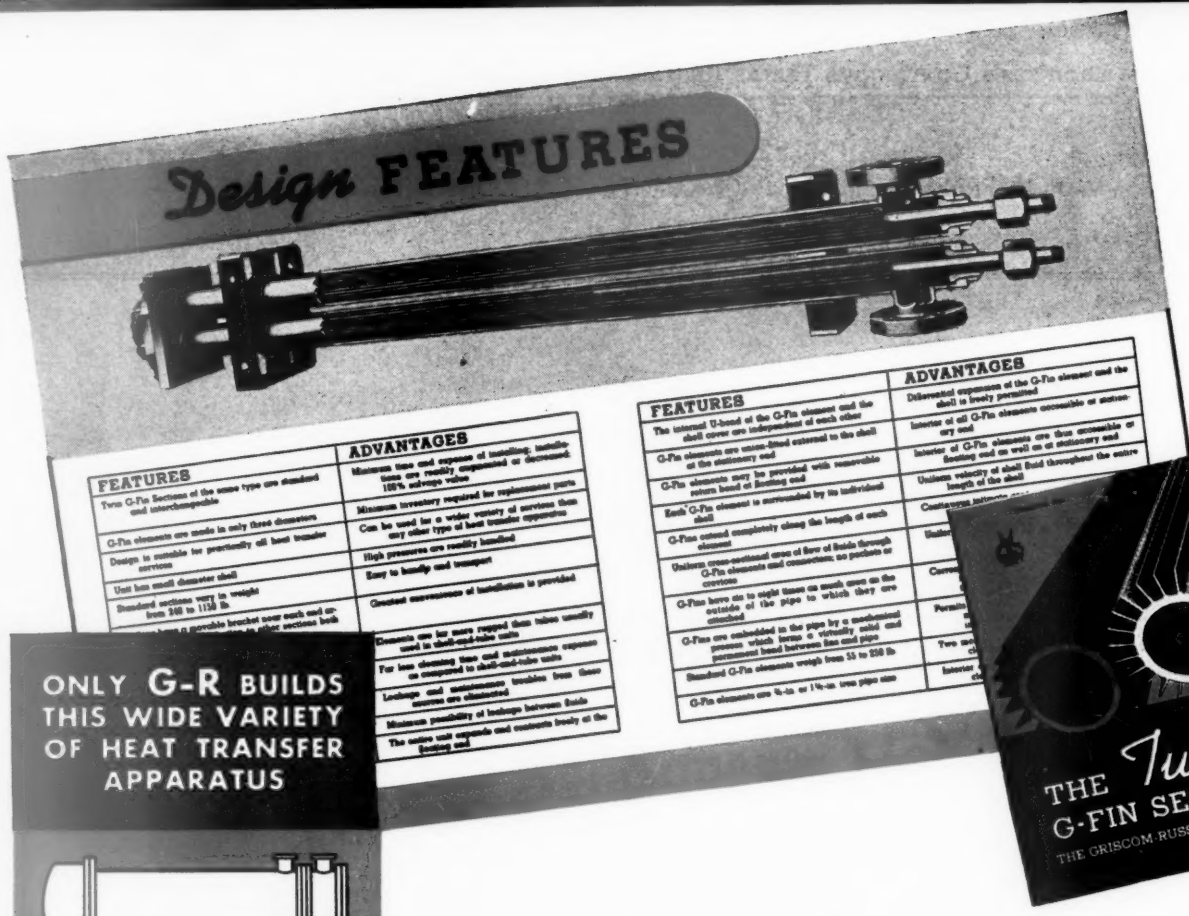
Required: A final blend of 105 lb. per sq. in.

Solution: Enter on the 212.5 lb. line on the horizontal scale (halfway between 200 and 225). Proceed upward to the 105 lb. per sq. in. final blend curve as indicated by dashed line and arrows. Then proceed to the vertical scale. The reading is 28.5 per cent.

Then, .285 by 10,000 gal. = 2850 gal. of 212.5 lb. per sq. in. depropanizer reflux to be added to obtain a final blend of 105 lb. per sq. in.

FIG. 9. Depropanizer reflux (as per cent of original contents) to add to 70 lb. butane mixture for desired vapor pressure.





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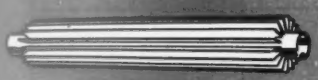

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TWIN G-FIN SECTION
The Universal Heat Exchanger

VOLUME CORRECTION FACTORS FOR C_4 HYDROCARBON MIXTURES

TABLE 2

Vapor pressure of C_4 hydrocarbon mixtures approximate values* at various temperatures corresponding to indicated values at 100° F.

Temp., °F.	Vapor pressure in lb. per sq. in. absolute at 100°F.								
	40	45	50	55	60	65	70	75	80
	(Approximate vapor pressure in lb. per sq. in. absolute at temperature indicated)								
130	63.5	71.0	78.3	85.5	92.6	99.6	106.5	113.3	120.1
125	59.0	66.0	72.9	79.7	86.5	93.1	99.7	106.2	112.6
120	54.8	61.3	67.8	74.2	80.6	89.6	93.1	99.3	105.4
115	50.8	56.9	63.0	69.0	75.0	81.0	86.9	92.8	98.6
110	47.0	52.7	58.4	64.1	69.7	75.4	81.0	86.6	92.1
105	43.4	48.7	54.1	59.4	64.7	70.0	75.3	80.6	85.9
100	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0
95	36.8	41.5	46.2	50.8	55.5	60.2	65.0	69.7	74.4
90	33.9	38.2	42.6	46.9	51.3	55.7	60.2	64.6	69.1
85	31.1	35.1	39.2	43.2	47.3	51.5	55.7	59.8	64.1
80	28.5	32.2	36.0	39.8	43.6	47.5	51.4	55.3	59.4
75	26.0	29.5	33.0	36.5	40.1	43.7	47.4	51.1	54.9
70	23.8	26.9	30.2	33.5	36.8	40.2	43.6	47.1	50.6
65	21.7	24.6	27.6	30.6	33.7	36.8	40.0	43.3	46.6
60	19.7	22.4	25.1	27.9	30.8	33.7	36.7	39.8	42.9
55	17.8	20.3	22.9	25.4	28.1	30.8	33.6	36.5	39.4
50	16.1	18.4	20.8	23.1	25.6	28.1	30.7	33.4	36.1
45	14.6	16.6	18.8	21.0	23.3	25.6	28.0	30.5	33.0
40	13.2	15.0	17.0	19.0	21.1	23.2	25.5	27.7	30.1
35	11.8	13.5	15.3	17.2	19.1	21.0	23.1	25.2	27.4
30	10.6	12.2	13.8	15.5	17.2	19.0	20.9	22.9	24.9
25	9.5	11.0	12.4	13.9	15.5	17.2	18.9	20.7	22.6

*Based upon known values for pure C_4 hydrocarbons

TABLE 3

Lb. per gal.*, corresponding to designated specific gravity at 60°/60° F.

Specific gravity at 60°/60°F.	Lb. per gal.	Specific gravity at 60°/60°F.	Lb. per gal.	Specific gravity at 60°/60°F.	Lb. per gal.	Specific gravity at 60°/60°F.	Lb. per gal.
0.630	5.252	0.610	5.086	0.590	4.919	0.575	4.794
0.629	5.244	0.609	5.077	0.589	4.911	0.574	4.786
0.628	5.236	0.608	5.069	0.588	4.902	0.573	4.777
0.627	5.227	0.607	5.061	0.587	4.894	0.572	4.769
0.626	5.219	0.606	5.052	0.586	4.886	0.571	4.761
0.625	5.211	0.605	5.044	0.585	4.877	0.570	4.752
0.624	5.202	0.604	5.036	0.584	4.869	0.569	4.744
0.623	5.194	0.603	5.027	0.583	4.861	0.568	4.736
0.622	5.186	0.602	5.019	0.582	4.852	0.567	4.727
0.621	5.177	0.601	5.011	0.581	4.844	0.566	4.719
0.620	5.169	0.600	5.002	0.580	4.836	0.565	4.711
0.619	5.161	0.599	4.994	0.579	4.827	0.564	4.702
0.618	5.152	0.598	4.986	0.578	4.819	0.563	4.694
0.617	5.144	0.597	4.977	0.577	4.811	0.562	4.686
0.616	5.136	0.596	4.969	0.576	4.802	0.561	4.677
0.615	5.127	0.595	4.961			0.560	4.669
0.614	5.119	0.594	4.952				
0.613	5.111	0.593	4.944				
0.612	5.102	0.592	4.936				
0.611	5.094	0.591	4.927				

*Lb. per gal. = 8.33722 × specific gravity at 60°/60° F. The values in this table are on the basis of weight in vacuo and 8.33722 lb. as the weight of a gal. of water. The values in NBS C410 are on the basis of weight in air and 8.32828 lb. as the weight of a gallon of water.

From National Bureau of Standards Letter Circular LC757.

...BEARINGS: HYATT supply 6 distinct advantages to HELIQUAD PUMPS

MORE THAN 20 YEARS AGO Hyatt Roller Bearings were first used in Kinney Manufacturing Company's Heliquad Gear Pump. These bearings provided six distinct advantages which have greatly helped to make this pump famous for performance:

1. **Almost total elimination of wear at bearing positions.**
2. **Packings stay concentric, wear evenly, require infrequent adjustment or renewal.**
3. **Main gears maintain correct operating relationship, last longer.**
4. **Timing gears continue to roll on their pitch lines, do not wear.**
5. **Simple external bearing mounting design is possible (due to Hyatts requiring little lubrication).**
6. **Pump starts easily, runs freely.**

Hyatt engineers will gladly consult with you on any present or future bearing problem you may have.

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION
Harrison, New Jersey • Chicago • Detroit • Pittsburgh • Oakland, California

R. S. Bubb appointed

The appointment of Robert S. Bubb as sales promotion and advertising manager of Dresser Manufacturing Division, Dresser Industries, Inc., Bradford, Pennsylvania, is announced by Hector P. Boncher, general manager.

R. S. Bubb

For the last 4 years Bubb, who holds the rank of lieutenant commander, has served with the United States Navy. Prior to his naval service, Bubb was engaged in industrial advertising and marketing activities in the New York area.

New firm name

The H. A. Smith Machine Company, Hopewell, New Jersey, has been renamed Rockwell Machine Company.

The Rockwell Machine Company is a subsidiary of the Rockwell Manufacturing Company and supplies precision machined parts to other subsidiaries and divisions of the Rockwell Manufacturing Company. It builds meter registers, regulators, and gage cocks.

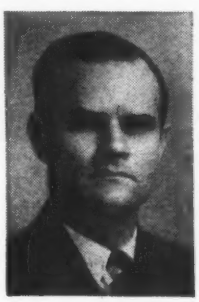
The change in name is accompanied with no personnel or policy changes. Herbert S. Rockwell continues as director of operations at the Hopewell plant.

Back with Cameron

Lt. Col. Jim Cowan, after 5 years with the U. S. Army Air Forces, has returned to his old job with the sales department of Cameron Iron Works, in Houston.

Heads Wheland Company

In 1914, at the age of 12, Gordon P. Street became an office boy for The Wheland Company of Chattanooga, Tennessee. Later he worked in the Wheland foundry and machine shop. A few days ago his election as president of The Wheland Company was announced by this pioneer manufacturer of oil field equipment and other heavy machinery. The young industrialist stated that his confidence in the petroleum industry prompted him to become financially interested in and accept the presidency of the firm.



Gordon P. Street

After his early experience in the Wheland office and plant, young Street joined his father and uncle who were the founders and owners of Street Brothers Machine Company, well known pioneer engineering and manufacturing concern. The Wheland Company has long been closely associated with the Street enterprises and served largely as the principal manufacturing end of the Chattanooga organization.

During the war Gordon Street coordinated the production of 90 mm. guns and shells, windlasses, and other ordnance equipment for the army and navy. He is widely known in the oil business and industrial circles and has been active in many civic and community building enterprises.

The Wheland organization will continue intact, with E. F. Wheland serving as chairman of the board, Charles W. Wheland, vice president, O. L. Martin, secretary-treasurer, George Campbell, chief engineer, and Ralph E. Shafer, sales manager. A. C. Willingham, former member of the firm and sales manager, died several months ago after a long illness.

John Leschen passes

John A. Leschen, vice president of A. Leschen and Sons Rope Company, St. Louis, Missouri, passed away November 13, it has been announced from company headquarters.

L. L. Rector entertains with barbecue

Members of the petroleum industry were treated to a barbecue with all the trimmings by the Rector Well Equipment Company, Inc., Ft. Worth, Texas, December 5, at noon.

Guests were shown through the machine and testing shop by L. L. Rector while company employes heaped temporary tables among the lathes with barbecue, pickles, onions, olives, potato salad, and gallons of hot coffee. A magic show was given at the close of the buffet style meal.

Rector company employe provides magic tricks for guests at barbecue.

Left to right: Lewis Finch, Stanolind Oil and Gas Company; W. J. Clay, Clay Brothers Drilling Company; Rex Rader, Stanolind, and Rufus Clay, Clay Brothers.

New Sun division

Appointment of James E. Pew as manager of a new division of natural gas and natural gasoline is announced by J. Edgar Pew, vice president of Sun Oil Company. The new division, which will function as a part of the company's production department, was created as a further development in an aggressive program for the conservation and efficient utilization of gas resources.

Simultaneously, the new manager announced the appointment of Charles E. Webber as his assistant. Their headquarters will be in Philadelphia.

Pew, formerly superintendent of the Virginian Gasoline and Oil Company, Charleston, West Virginia, served 45 months with the Petroleum Administration for War in Washington, and was director of the agency's Natural Gas and Natral Gasoline Division prior to his new appointment. Now 45 years old, he has been associated with the petroleum and natural gas industries since childhood, following in the footsteps of his father, John G. Pew, who was president of the Peoples Natural Gas Company, Pittsburgh, before he became president of Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, in 1918. Earlier this year he received the Hanlon Award for outstanding, meritorious service to the natural gas and condensate industries.

Several projects have already been programed by the new Sun Oil division, including pressure-maintenance operations and the construction of gas cycling plants. One of the first objectives will be the elimination of gas flares by devising operating methods for making the conservation of this gas economically feasible. Deeper drilling and increased gas-condensate discoveries have multiplied gas problems for the oil producers, the new manager reports.

NO COMPUTATION NECESSARY
Readings, accurate to the second decimal, are read directly from the chart. Readings to the third decimal can be made by easy approximation.
ARCCO-ANUBIS GAS GRAVITOMETERS
Once calibrated and properly installed, the Arcco-Anubis Gas Gravitometer requires no further attention. The unit is practically frictionless. No electric motors, pressure regulating valves or other complex equipment to get out of order. The gas flow is continuous, thus the most minute changes in specific gravity are recorded the instant they occur.
Arcco-Anubis Gas Gravitometers have proved themselves by giving accurate readings under the most adverse working conditions. Hundreds are in continuous use, in pipe lines and refineries of major companies all over the country.
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RECORDING CHART CO.
3113 E. 11th St. Los Angeles 23, California
SEND FOR COMPLETE LIST OF ARCCO CHARTS

Hight sales manager

The appointment of Hanford Z. Hight as sales manager of Dresser Manufacturing Division, Bradford, Pennsylvania, is announced by Hector P. Boncher, general manager.

H. Z. Hight

For the last 3 years Hight has served with the United States Navy as an air combat intelligence officer. His last duty was aboard the escort carrier, U.S.S. Shipley Bay, attached to the Third and Fifth fleets during the Okinawa operation.

Prior to his service with the armed forces, Hight was district manager of Dresser Manufacturing Division in the mid-west territory.

Glueck retires

Edgar L. Newhouse, Jr., president of Federated Metals Division, American Smelting and Refining Company, announces the retirement of Isador Glueck after 31 years' service with Federated and its predecessor companies.

Isador Glueck

Glueck began his career in the scrap metal industry in 1914, at the St. Louis plant of a predecessor of Federated. In 1921, he was placed in charge of Federated's New York office, heading up the sales and export department. In 1925, he became manager of the Chicago plant and in 1937, returned to New York as general manager of the eastern division of Federated. He is retiring from this position as of December 31, but will continue to serve the company in a consulting capacity.

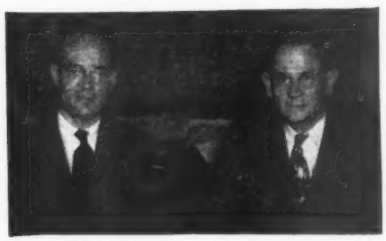
One of the best known figures in the scrap metal industry, Glueck has been vice president of the Non-Ferrous Ingot Metal Institute since its inception; chairman of the Code Authority of the

Ingot Brass Industry of NRA, and a member of the advisory committee of American Smelting and Refining Company for the last 8 years.

Texas Gulf representative

Fisher Governor Company, Marshalltown, Iowa, manufacturers of automatic control equipment, announces the appointment of the Puffer-Sweiven Company as its exclusive representative in the Texas Gulf Coast area. The office address is Room 605, Merchants and Manufacturers Building, Houston 2, Texas.

Kenneth L. Puffer has been associated with Fisher Governor Company for more than 20 years, both as a member of the



C. E. Sweiven (left) and Kenneth L. Puffer

Marshalltown engineering and research staff and as a sales engineer in the field. Since 1933 he has served the Gulf Coast area from the Houston office.

C. E. Sweiven has had 7 years' field experience in selling and servicing Fisher control equipment. Prior to his affiliation with the Fisher organization, he spent several additional years in the automatic control field. For the last 2 years he has served the Fisher company in the home office as sales engineer.

Sperry-Sun expansion

The Sperry-Sun Well Surveying Company has recently acquired by outright purchase the building and property at 3118 Blodgett Avenue, Houston, Texas, on which its present Gulf Coast headquarters are situated.

The property comprises more than 2 acres of land, allowing ample room for the expansion of the Sperry-Sun services, which are planned for the near future.

The Houston office is the distributing center for all Sperry-Sun instruments and services used in the Gulf Coast and the Mid-Continent. It has a well-equipped instrument maintenance and repair shop.

Roland Ring, assistant to Sperry-Sun's vice president and general manager, G. L. Kothny, is in charge of the Houston office.

Sperry-Sun is also establishing a new research and development department in the suburbs of Philadelphia where new equipment and new services will be developed and tested prior to making the new equipment available to the Houston office for field tests. A number of new services for the drilling industry are in the course of development.

This new J-M machine
DOUBLE COATS
and DOUBLE WRAPS
in one operation!

This machine was especially developed for J-M by Crutcher-Rolfs-Cummings of Houston.

Here's the way to get "plus" protection for your pipelines in double-quick time!

THIS ingenious J-M machine alternately applies *two* layers of Johns-Manville Asbestos Felts and *two* coats of enamel to give protection against severe corrosive conditions.

Pioneers in the manufacture and application of asbestos wrappings . . . Johns-Manville has gone a step further with this new machine.

The J-M Coating and Wrapping Machine can save time and money for you, just as J-M Asbestos Pipeline Felts safeguard the enamel on your lines against soil stress and distortion. For further information, write Johns-Manville, 22 East 40th Street, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *Asbestos* Pipeline Felts

Organizes new firm

Robert A. Graff, formerly chief process engineer of the Gas Processes Division of the Girdler Corporation, has organized the Graff Engineering and Equipment Company, 505 South Third Street, Louisville, Kentucky. This company will engage in general gas engineering, offering, engineering and equipment in the field of gas production, purification, and dehydration.

Robert A. Graff

Joins Ostrander

G. L. Van der Boom, formerly advertising manager of Southwest Welding and Manufacturing Company, Alhambra, California, has joined Russell P. Ostrander, Advertising, Los Angeles, in the capacity of account executive.

Ven der Boom has more than 10 years' experience in the sales and advertising divisions of industrial equipment concerns. He will be active as an account executive mainly in the automotive, construction equipment, and steel fabricating fields. His addition to the staff of Russell P. Ostrander, Advertising, will further expand the agency's facilities in industrial advertising fields.

Gottwald to South America

A. L. DiGiulian, vice president of Rockwell International Corporation, points to Latin America area that Gottwald will cover.

H. "Red" Gottwald, for 17 years a service engineer for Pittsburgh Equitable Meter Company-Nordstrom Valve Company in the metropolitan New York territory, has been assigned to the Rockwell International Corporation. Rockwell International Corporation is the new name for the organization formed as Pittsburgh International Corporation to handle export sales and service of the company's products. Gottwald has been appointed special representative for Latin America by A. L. DiGiulian, vice president and general manager of the export firm. He is now making a preliminary trip covering the important markets in South America.

Gottwald is a graduate of Syracuse University. His background of experience among the utilities, major oil companies, and engineering firms will be of aid to a similar class of equipment users in Latin America.

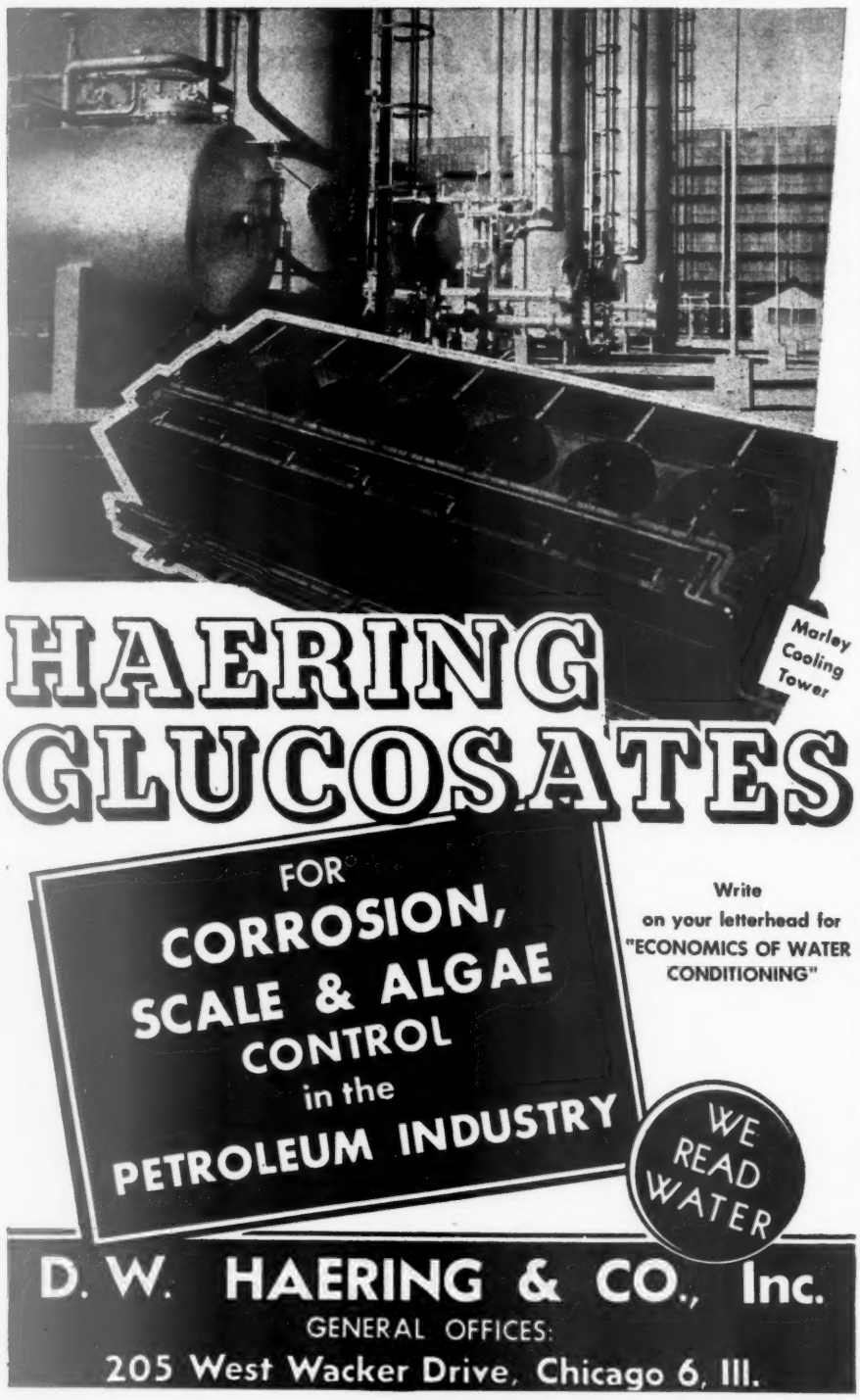
Smith plant manager

G. A. Tompson, vice president of American Well and Prospecting Company, a subsidiary of Bethlehem Steel Corporation, announces the appointment of I. C. Smith as plant manager at Corsicana, Texas, effective December 1.

I. C. Smith

Smith, a native of Mineola, Long Island, New York, attended Lehigh University and was graduated with a B. S. degree in industrial engineering in 1935. Immediately after graduation, he entered the training course offered by the Bethlehem Steel and received extensive instruction in all phases of the company's production activities. On completion of the course, he was given an assignment in the machine shop and made steady progress, and at the end of the war he was in charge of one of Bethlehem's plants making bombs and shells.

Smith succeeds J. E. Rittersbacher who resigned effective November 30.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HAERING GLUCOSATES
FOR CORROSION, SCALE & ALGAE CONTROL in the PETROLEUM INDUSTRY
Write on your letterhead for "ECONOMICS OF WATER CONDITIONING"
WE READ WATER
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GENERAL OFFICES:
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Changes approved

At a special meeting, stockholders approved the recommendations of the board of directors that the name of Pittsburgh Equitable Meter Company be changed to the Rockwell Manufacturing Company, and that stock be split, four shares for one.

W. F. Rockwell

Directors of Pittsburgh Equitable Meter Company, will continue as directors of the Rockwell Manufacturing Company. Col. Willard F. Rockwell, for whom the company is named is chairman of the board and president. Serving with him on the board are J. Frank Drake, Meredyth H. Ewing, Edgar W. Meyers, Henry A. Phillips, and Willard F. Rockwell, Jr., Pittsburgh; John L. Merrill, Sven J. Nordstrom, and Herbert S. Shuey, San Francisco; Elisha Walker, New York, and W. F. Crawford, Chicago.

The Pittsburgh Equitable Meter Company name will be continued as a subsidiary of the Rockwell Manufacturing Company, marketing measuring equipment for water, gasoline, oil, and other liquids, manufactured in plants in Pittsburgh, Brooklyn, and Hopewell, N. J.

The increasing scope of the company's manufacturing facilities and products prompted the change in the company name. In addition to the Pittsburgh Equitable Meter Company, the Rockwell Manufacturing Company is the parent company of the Merco Nordstrom Valve Company, Oakland, California.; Rockwell Machine Company, Hopewell, New Jersey; The Edward Valve and Manufacturing Company, Inc., East Chicago, Indiana; The Delta Manufacturing Company, Milwaukee, Wisconsin; The V. & O. Press Company, Hudson, New York; The Crescent Machine Company, Leetonia, Ohio; Rockwell International Corporation, New York, New York, and Monessen Foundry and Machine Company, Monessen, Pa.

At the same time the name change was approved, stockholders voted to increase the authorized stock from 500,000 to 4,000,000 shares, and to split outstanding shares, four for one. The present shares now outstanding are therefore increased.

Officers of the Rockwell Manufacturing Company include Col. Rockwell, president; W. F. Rockwell, Jr., vice president and general manager; J. Frank Drake, W. S. Potter and A. J. Kerr, vice presidents; H. A. Phillips, vice president and secretary; Edgar W. Meyers, treasurer, and E. W. Meyers, Jr., controller.

Nomads hear Pyle

The Tulsa chapter of Nomads held a luncheon meeting in the Tulsa Club roof dining room November 29. Howard C. Pyle, vice president of the Bank of America, Los Angeles, California, who is in charge of the institution's new oil division, was the speaker. His subject was "Supplying Oil to the Armies of Europe."

Pyle, who has a B.S. degree from the University of California, M.S. and petroleum engineering degrees from University of Southern California, and formerly was chief petroleum engineer of the Union Oil Company of California, played a conspicuous part in directing petroleum supply to American armies and air forces in Europe, including construction and operation of the now famous pipe lines across Europe.

He left Union Oil in 1943 to enter the U. S. Army as petroleum engineer with rank of captain in the Washington office of the chief engineer. He was soon promoted to Chief, Oil Supply and Rehabilitation and Development branch of the Quartermaster General's office, with the rank of major.

In 1944 he was assigned to the general staff of Supreme Commander Eisenhower in the E. T. O. as petroleum officer. In 1944, he was promoted to lieutenant colonel and served as deputy chief of the general staff, Oil Branch, Communication Zone.

A NEW, FAST AND ACCURATE METHOD FOR THE INTERPRETATION OF SURVEYING RECORDS

The computation of the course of a bore hole from survey records obtained is a simple but tedious procedure. The mathematics involved are known to any high school student.

An accurate survey of a bore hole involves at least one hundred (100) or more records. The calculations, based on these records, require considerable time. There is also the possibility of serious errors being made in such calculations.

To provide a speedy and accurate procedure to determine the course of a bore hole the Sperry-Sun Well Surveying Company has prepared a set of Tables which completely eliminate the making of calculations and immediately furnish the desired results. These Tables give the results for angles of inclination in quarter degrees from 0 to 31 and in half degrees from 31 to 45 and in degrees from 45 to 55 for bearing angles in degrees from 0 to 90.

To obtain the result it is only necessary to refer to the Table, select the vertical column of angle of inclination and the horizontal column of bearing and obtain the Latitude, which is the distance North or South, and the Departure, which is the distance East or West from the vertical through the mouth of the well or from the vertical through the preceding point.

The Tables give the values of the Latitude and Departure for each one hundred (100) feet course length. They also give the true vertical depth for each angle of inclination. Geometric calculations are eliminated and only in cases where the course length is more or less than one hundred (100) feet is it necessary to multiply proportionately the values obtained from the Tables.

The Tables also contain a section dealing with the Correction of Magnetic Compass Records, a subject which is frequently overlooked when magnetic compasses are used for recording the angle of bearing. This section not only explains the influence of permanent magnetism of the bit and drill pipe upon the compass record obtained, but gives information for the determination of the strength of the magnetic field produced by a drill stem or drill bit and for the determination of the Angle of Correction.

These Tables have been prepared with great effort and expense by Sperry-Sun Well Surveying Company and have been used in their organization for many years. Sperry-Sun has received many requests for these publications and on account of their usefulness to the oil industry, Sperry-Sun has agreed to their publication. These Tables can now be obtained at the price of $5.00 per copy though the publishers of this magazine.

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WHEN YOU WANT .... *The Best* CONTROLLED PRESSURE EXPANSION SWAB

Because of the *exclusive controlled expansion feature* of the "Double E" Swab, you are assured of full fluid recovery with minimum wear of cups. You do have the ultimate advantage when you can control the pressure of the cups against the wall while swabbing. With no load lost and minimum wear you have the best.

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PETROLEUM ENGINEER, educated in production at Colorado School of Mines and University of Oklahoma; 1938 graduate, married, now lieutenant colonel on Army terminal leave, desires position drilling, production, proration, or geology. Have roughneck, roustabout experience, 1 year assistant proration engineering major company, 2 years Gulf Coast and research editor, feature writer, for petroleum engineering journal, 4½ years Army, all with troops. No foreign work, but free to locate anywhere in U. S. Address Box 39, care of *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

WELL GEOLOGISTS

To watch progress of wells in Eastern Venezuela. Care for samples, picks, casing points, core points, etc. Write

THE ATLANTIC REFINING COMPANY

Room 900 P. O. Box 7258

PHILADELPHIA 1, PA.

LATE type Wilson Power Rotary Drilling Rig equipped with Hydro-Matic brake, practically new, capable drilling 8000 feet, complete in every detail, including 7500 feet first class drill pipe. For particulars telephone 1300 or write P. O. Box 2108, Longview, Texas.

FOR SALE

6615 ft. —7.4" OD x ½" Wall x 27'-29' long, SAE 1035, New H.R. Seamless Steel Tubing.

539 pcs.—2⅜" OD x 8 Rd. thrd. x 4⅞" Upset Tubing.

3878 pcs.—7" OD x 8 Rd. thrd. x 5¾" Casing Tubing.

60 pcs.—7⅝" OD x 8 V thrd. x 5⅛" Drive Tubing.

4 pcs.—10¾" OD x 8 V thrd. x 8½" Casing Tubing.

S. MANN COMPANY

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"Best Bet Yet"

These oil-proof, wear-resistant, plastic tubing protectors are an integral part of the tubing collar. Made in all sizes, they prevent the metal-to-metal contact that has caused many expensive "wet" jobs in pumping wells in the past.

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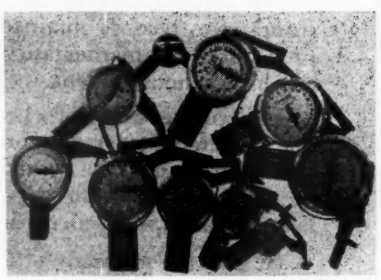

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With a Line Scale you know the pull on the line, and the weight on the bit in pounds. Accurate, sensitive, rugged and economical.

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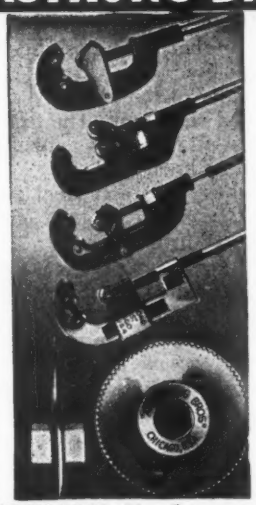
THE POSITIVE LEAK PREVENTER

Look for the Arm-and-Hammer
ARMSTRONG BROS.



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ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machined from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters. . . . *Write for Catalog.*

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Exploration work in Venezuela. Should have 3 years experience in mapping Rocky Mountains, California or Foreign. Write to

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WANTED: CHIEF ENGINEER

Executive with ability to take full charge of all engineering, research, and development. Must be familiar with oil refinery equipment and construction, general steel plate construction, and general process equipment. Location, midwest. Write giving full information, age, education, experience, salary, references, etc. Box 36, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

WANTED: MINING or PETROLEUM ENGINEER by Major Oil Company. Recent graduate or with some experience, for Exploration and Production Engineering work. Training course if inexperienced. Write Box 32, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

WANTED: GEOLOGIST by Large Major Oil Company. Minimum requirements B.S. or B.A. degree, geology major. Previous experiences not required. Write Box 34, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

WANTED: MECHANICAL ENGINEER

Major Oil Company requires graduate Mechanical Engineer for Production Department. Either experienced or inexperienced. Write Box 33, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

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An oil field service organization has openings for engineers in technical oil field service. Men with one or two years' experience in oil production and degree in Petroleum, Electrical or Mechanical Engineering are given preference. Permanent position with long established company. Write giving full details on education, experience, age and marital status. Attach small photograph. Address replies to Box 38, care of *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

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For Venezuela, five years' experience, preferably foreign.

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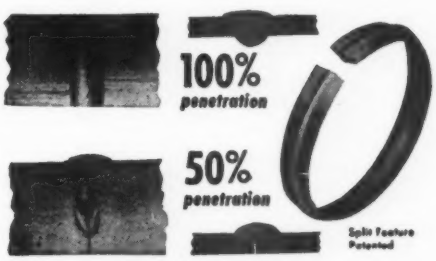
WEDGE
Split CHILL RINGS
REINFORCE
Joints so you can
SAFELY *use* **THIN WALL PIPE**

Many engineers are saving money and at the same time getting a stronger line by using WEDGE Chill Rings with the patented SPLIT Feature on standard pipe. WEDGE Chill Rings REINFORCE the joints and make them the strongest part of the line. In the past thick pipe was necessary because of the joints—NOW that WEDGE Chill Rings REINFORCE the joints much lighter pipe can be used. This reduces the weight of pipe and also the cost. WEDGE Chill Rings reduce the aligning time, also welding time and pays out in many ways. Write.



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SAVE MONEY

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PIPE LINE SPECIAL

Double-bolster trailer for use with truck not equipped with platform body. Especially for handling long material. Supplied with two rigid bolsters so that tongue does not carry any load. Has demonstrated its worthiness under most severe conditions.

Order NOW for Early Delivery
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AMERICA'S largest selling PUMPS Provide Water For Industrial Service, Domestic Uses & Irrigation • Peerless offers the most complete line of vertical and horizontal pumps. Because of the extensiveness of the line, a pump of the size and exact type best suited for your pumping conditions, which makes for greatest economy of operation, is available to you. The Hi-Lift illustrated here is furnished in sizes of from 500 to 3,500 gallons per hour. The Hydro-Foil (Propeller Type) up to 220,000 gallons per minute.

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The Water King, shallow well type, utilizing the HI-LIFT principle ingeniously applied in simplest form, in sizes up to 1,300 gallons per hour. **The Peerless Jet Pump,** for deep or shallow wells, is available in sizes up to 5,000 gallons per hour.

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PEERLESS PUMPS

PEERLESS PUMP DIVISION
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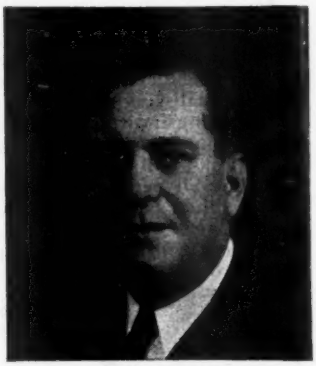
Don Bowers passes

Funeral services for Don Sprague Bowers, 58, president of W. C. Norris, Manufacturer, Inc., of Tulsa, Oklahoma, were held November 14. He died of a heart ailment on November 11.

Born in Caneyville, Kentucky, on June 10, 1887, Bowers went to Oklahoma with his parents in 1896, and the family settled at McAlester. He graduated from the public schools of McAlester and attended Hanover College at Madison, Indiana.

He first became associated with the oil industry in 1909, going to Tulsa to work in the offices of the Gulf Pipe Line Company, and in 1912 went to Tampico, Mexico, to work in the company's office there.



D. S. Bowers

He joined the Norris organization, manufacturers of oil well supplies, in 1915, and in his 30 years with the company held the positions of general manager, executive vice-president, and was elevated to president following the death of W. C. Norris, founder of the company.

Survivors are the widow, Mrs. Elsie Norris Bowers, and a son, Wilbur Don Bowers, both of the home; three daughters, Mrs. Clyde King, Jr., of Tulsa, Mrs. C. Pedrick, Jr., of Newburg, New York, and Mrs. Claude Williams of Lebanon, Missouri; his mother, Mrs. Alice Sarlls of St. Louis, Missouri, and two sisters, Mrs. Madge Anderson of Tulsa, and Mrs. H. J. Osborne of St. Louis.

Maloney Tank name changed

O. W. Maloney, president of Maloney Tank Manufacturing Company, announces that as of December 1 the firm became the Maloney-Crawford Tank and Manufacturing Company of Tulsa, coincidental with an expansion in the oil field sales and service facilities.

Harold D. Crawford, who recently purchased a substantial interest in the Maloney firm, has been named secretary-treasurer. He is the son of the late David Crawford of Parkersburg, West Virginia, who with his brother John, established the Parkersburg Rig and Reel Compaany.

Maloney is the son of the founder of the Maloney company, who originally patented the bolted steel tank. The firm, established in 1915, is one of the oldest oil field tank and equipment manufacturers in the Mid-Continent area.

Four veterans of the Parkersburg Rig and Reel Company have resigned from the Crawford Tank and Supply Company at Dallas to join the Maloney-Crawford firm. They are:

S. P. Wallace, formerly president of Crawford Tank and Supply Company, now general sales manager with headquarters in Dallas; L. Glenn Rader, formerly Crawford director and district manager at Houston, now Maloney-Crawford division manager at Houston; Arther J. De laHoussaye, formerly Crawford representative in southern Louisiana, now district manager for Maloney-Crawford in New Orleans; W. B. Brawner, representative at Corpus Christi for Crawford, now Maloney-Crawford district manager for southwest Texas, keeping Corpus Christi headquarters.

Other additions and changes in the organization are:

E. C. Kopp, of Hanlon-Waters, Inc., becomes division manager for Maloney-Crawford for North and West Texas, with headquarters at Fort Worth. Dugan Blakeney, Hanlon-Waters, Inc., representative at Odessa, goes with Maloney-Crawford at the same place.

R. H. Guthrie, H. H. Guthrie, and Frank Gurtler remain in the West Texas Maloney-Crawford headquarters at Odessa.

D. E. Amy of Houma, Louisiana, transfer from Crawford Tank and Supply Company to Maloney-Crawford at Lafayette. C. E. Henderson similarly transfers from Crawford to Maloney-Crawford at Lake Charles, Louisiana.

C. L. Pirtle, J. B. Graham, Miss Alice Wolf, all of Houston, transfer from Crawford also.

Carl Kinser and Lester Moore, Maloney representatives for

several years at Corpus Christi, remain in their same capacities. Carl Folkner, district manager for Maloney at Artesia, New Mexico, is promoted to division manager in charge of New Mexico, Colorado, and Wyoming.

F. L. Bruckner, formerly of Parkersburg and Crawford, joins the sales department of Maloney-Crawford in Tulsa.

T. J. Costello continues as sales representative in Oklahoma, and Guy Stevenson continues as field man for Maloney-Crawford at Artesia, New Mexico.

Maloney-Crawford will continue to manufacture and sell bolted steel tanks, welded steel tanks, oil and gas separators, and a new and improved line of heater treaters.

Decker completes trip

E. L. Decker

E. L. Decker, vice president of the Martin-Decker Corporation, Long Beach, California, has returned from an extensive sales trip throughout the Mid-Continent and Gulf Coast areas. Decker attended the drilling contractors' meeting in Oklahoma, and the divisional managers meeting of the Reed Roller Bit Company at Tulsa, Oklahoma. His itinerary included Shreveport, Louisiana; Houston and Fort Worth, Texas; Natchez and Laurel, Mississippi; southern Louisiana and West Texas.

Rockwell subsidiary changes name

Directors of the Merco Nordstrom Valve Company, subsidiary of the Rockwell Manufacturing Company, of Pittsburgh are announcing the shortening of the name to Nordstrom Valve Company.

The Nordstrom Valve Company builds Nordstrom lubricated plug valves, air and service cocks, Nordco lubricants and valve accessories. The principal manufacturing facilities for Nordstrom valves are in Oakland, California, with additional facilities in Pittsburgh and East Chicago, Indiana.

There are no changes in the personnel or sales policies of the company.

Fagg chief engineer

G. A. Tompson, vice president of American Well and Prospecting Company, a subsidiary of Bethlehem Steel Corporation, announces the appointment of Lee Fagg as chief engineer effective November 1. Fagg is at the company's plant at Corsicana, Texas. He was born and reared in Corsicana, attended Texas A & M and was graduated in 1928 with a B. S. degree in mechanical engineering.

After several years of plant and field experience with the National Supply Company, he was employed by the American Well and Prospecting Company as sales engineer and assistant chief engineer.

Lee Fagg

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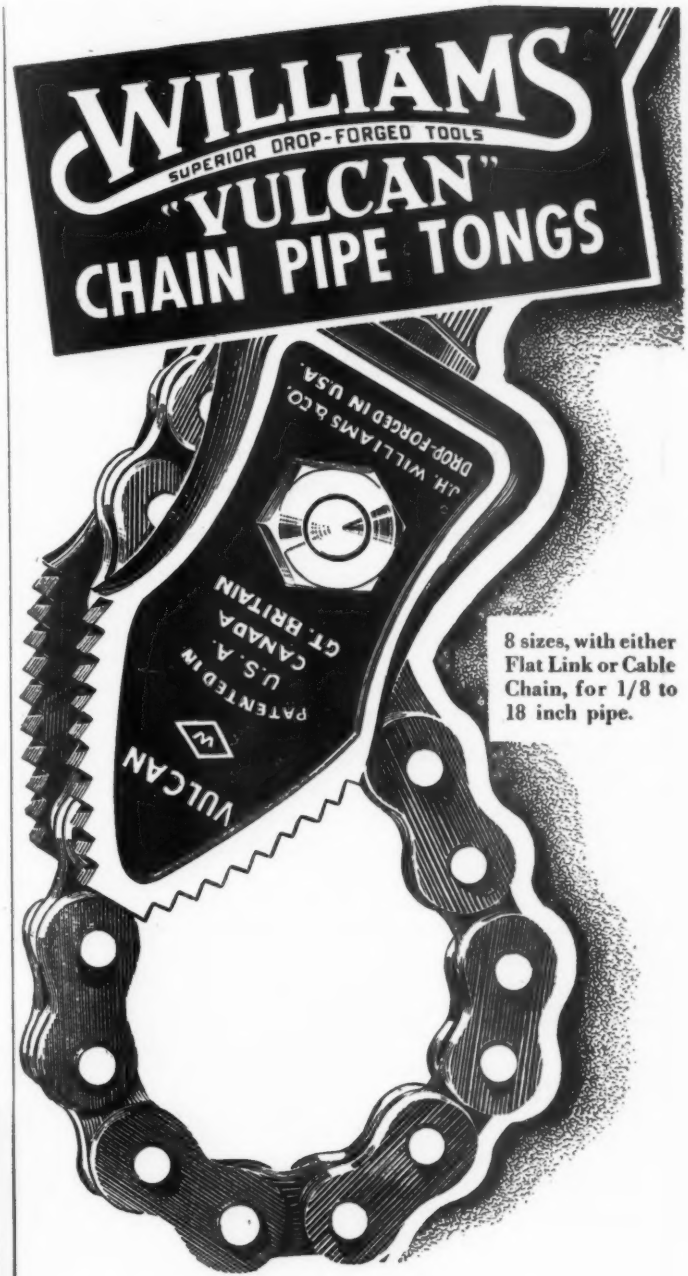

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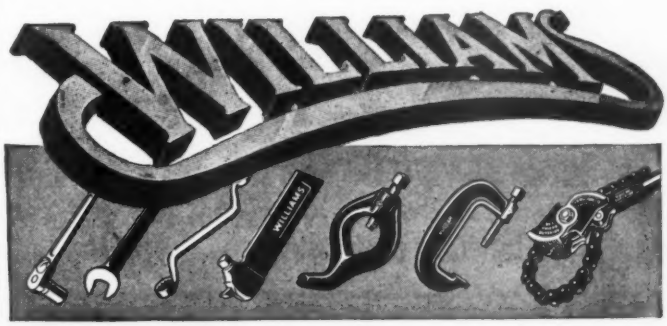

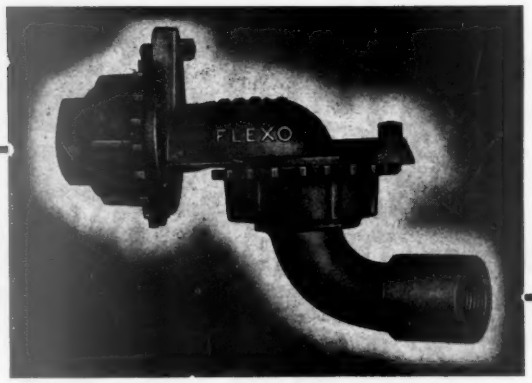

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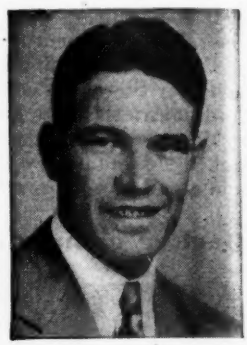
Pinkard joins Rector Well Equipment

J. L. Pinkard, recently of the U. S. Army, has joined Rector Well Equipment Company, as sales representative, covering the West Texas territory. He will assist W. P. Knight, who has represented the company in this area for many years.



J. L. Pinkard

Pinkard has been in the Army since May, 1941. Thirty-nine months of his service were spent overseas, in the Asiatic-Pacific area, where he saw considerable action. While in service he was master sergeant in charge of construction.

Prior to entering the Army, Pinkard was with the Producers Drilling Company for 5 years, serving both in the drilling and production departments. He is a native of Ardmore, Oklahoma, and spent several months as construction superintendent for the Oklahoma Highway Department.

Service company for Venezuela

United Oilwell Service, S. A., of Caracas, Venezuela, announces the organization of a service company that will offer to the petroleum industry of Venezuela many of the services currently being performed by Dowell Incorporated of Tulsa, Oklahoma.

One of the services that will be offered is the acidizing of oil wells. Laboratory tests indicate that very useful results may be obtained through the use of acid in improving the producing characteristics of wells in many of the Venezuelan fields, officials of the company state. In the past this procedure has been tried to a limited extent in Venezuela, but the handling of acid in large quantities encountered transportation difficulties that prevented wide application. These difficulties have now been overcome, and arrangements have been made to ship the necessary quantities of acid to Venezuela.

The principal base of operations will be at Km. 100 on the Barcelona-San Tome Road, at which point United Oilwell Service is constructing a modern camp, laboratory, warehouse, and shops, as well as storage facilities for acid.

The procedure for acidizing oil wells will be carried out under a licensing agreement between Oilwell Service, S. A., and The Dow Chemical Company.

As soon as possible, United Oilwell Service plans to expand its services to include the use of plastics in water shut-offs, the use of the Dowell Electric Pilot for determining relative permeabilities in oil wells, water locating apparatus, and mud engineering.

Plans are also being made for the extension of these services to the Maracaibo area.

The general offices of the United Oilwell Service, S. A., are in Caracas, and Charles W. Fowler is president and general manager of the organization. Phil J. Lehnhard, formerly of Dowell Incorporated, occupies the post of chief engineer.

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New company organized

Stephen A. Brooks and seven associates, each with extensive experience in rotameter manufacture and application, have organized the Brooks Rotameter Company, a corporation capitalized at $100,000. A factory has been acquired at Lansdale, Pennsylvania, with 18000 sq. ft. of floor space and manufacture has begun on all types of rotameters for flow rate measurement and control.

Stephen A. Brooks

Brooks is a graduate chemical engineer with a wide experience in chemical manufacture and instrumentation. For the last 6 years he has been vice president of Fischer and Porter Company, in charge of sales and advertising.

Harry H. Long will be chief fluids engineer in charge of specifications and calibrations. He will be assisted by James Anthony and Joseph Ducsik. Garbutt W. Aiman will have charge of precision rotameter tube manufacture. Jack Bradley will manage production and Lou Rosenblum will handle purchasing and accounting.

Opens branch office

H. C. Smith Oil Tool Company, Compton, California, announce the opening of a branch office in Casper, Wyoming, at 328 South David Street. Jack Bush has been appointed branch manager of the new office.

Elected to board

Fred H. Haggerson, president, Union Carbide and Carbon Corporation, announces the election by the board of directors of the following officers of the corporation: Dr. Joseph G. Davidson, vice president, chemicals division; Stanley B. Kirk, vice president, industrial gases division; James W. McLaughlin, vice president, plastics division; William J. Priestley, vice president, alloys and metals division; John H. Rodger, vice president, railroad division; Arthur V. Wilker, vice president, carbon division; H. Earl Thompson, vice president, engineering; Robert J. Hoffman, vice president, industrial relations, and Morse G. Dial, secretary-treasurer.

The new officers of the parent corporation are officers of important subsidiary companies, Dr. J. G. Davidson is president of Carbide and Carbon Chemicals Corporation; S. B. Kirk is president of The Linde Air Products Company; J. W. McLaughlin is president of Bakelite Corporation; W. J. Priestley is president of Electro Metallurgical Company; J. H. Rodger is president of the Oxweld Railroad Service Company; A. V. Wilker is president of National Carbon Company, Inc.; H. E. Thompson is vice president and director of Carbide and Carbon Chemicals Corporation and Bakelite Corporation; R. J. Hoffman is director of various subsidiaries and president of Union Carbide and Carbon Research Laboratories, Inc.; and M. G. Dial is secretary-treasurer of many of these subsidiary companies.

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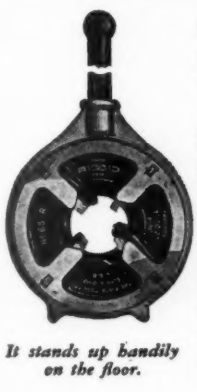

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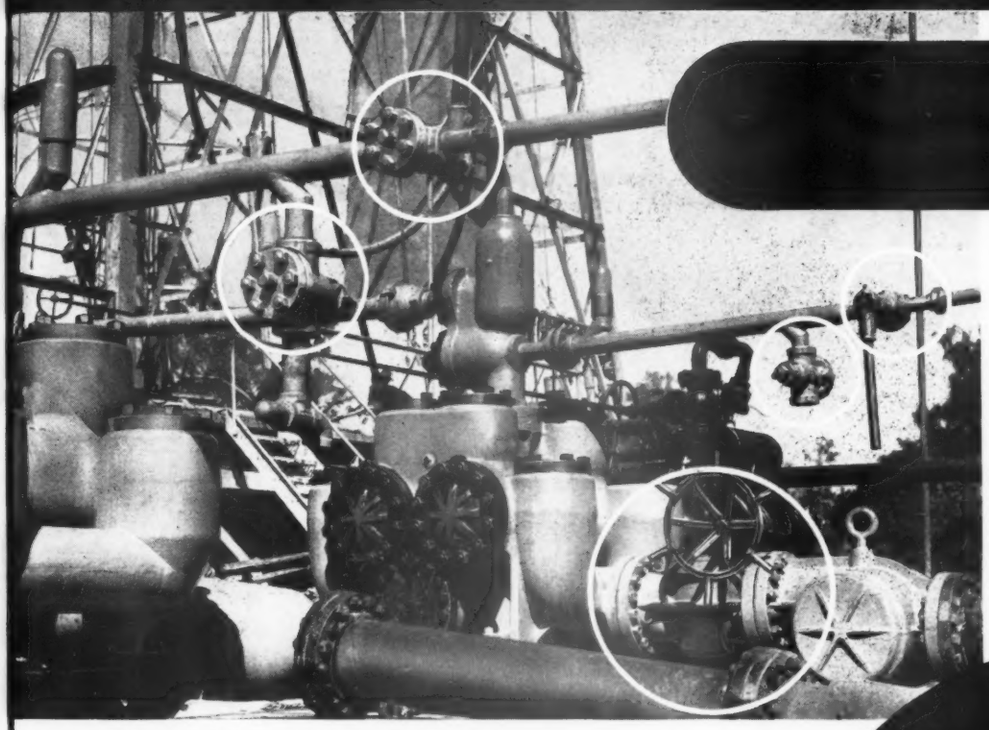

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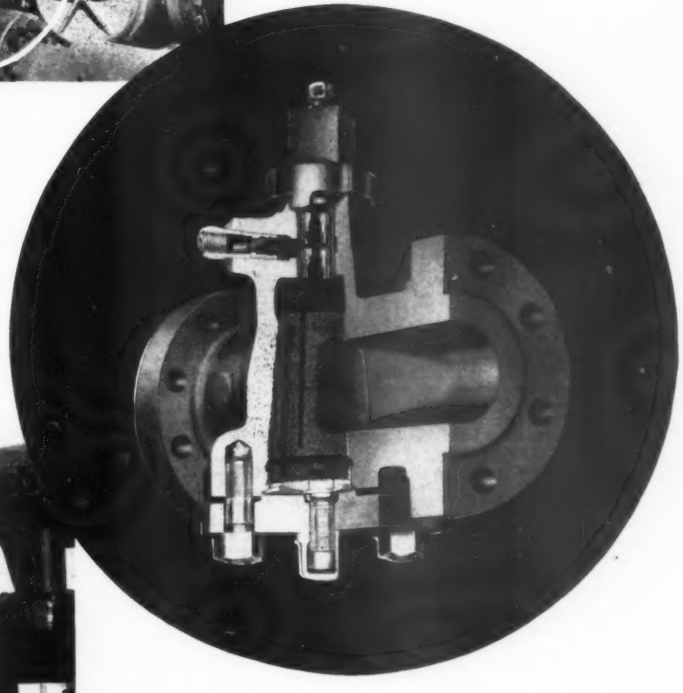

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